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THE PRESERVATION OF TIMBER.

REPORT OF THE COMMITTEE ON THE PRESERVATION OF TIMBER, PRESENTED AND ACCEPTED AT THE ANNUAL CONVENTION, JUNE 25TH, 1885.

WITH DISCUSSION.

The committee on the "Preservation of Timber" was appointed early in 1880.

Even before the gathering of statistics on forestry for the census of that year, it had become evident to engineers, from the increasing price and growing difficulty in procuring good timber, lumber and railroad ties in many parts of the United States, that several of the sources of such supplies were being rapidly exhausted, and that as a measure of both private and national economy it would soon become necessary for us to resort to the artificial preparation of wood against decay, as had been successfully done for years in Europe.

The principal questions before the committee were to determine which methods of preserving timber against decay were most successful, and which were best adapted to the needs and current practice in this country.

Designing to base its report only upon well ascertained facts, the committee undertook to gather as fully as practicable the records of the experiments that had thus far been made in the United States, in order to compare them with each other, and with the results in Europe.

During the first year the committee accomplished but little. It had to overcome the public indifference which then existed on the subject, and the popular impression that probably no good would result from the investigation, as it was doubted whether there were any successful processes applicable to this country. It also had to ascertain where the much-scattered information desired was to be found.

This it was determined to do by circulars and correspondence, in order to find *who* possessed the data of past experiments, and *who* would be willing to impart it. For this purpose the committee issued some 2 000 circulars, with postal cards inclosed, on which a form of answer was printed. It corresponded with some 350 persons, gathered and studied some 55 pamphlets, examined 104 patents, and thus obtained the results of some 147 experiments, which are hereinafter tabulated and commented upon.

When this information began to come in, the committee found it very confusing. Not only were there the greatest possible differences in the opinions which were expressed, but the facts seemed to contradict each other. Apparently the same processes seemed to give different results, and these again differed from the European experience.

The committee, therefore, made a preliminary report to the Washington Convention in 1882, and asked for more time to ascertain how each experiment had been carried out, and to sift the evidence.

This was very tedious, both because there were few written records of these experiments and we had to rely upon personal recollections, and because the various persons who possessed such remembrance (and sometimes it required three or four to recollect the details of one experiment) had changed their business connection, and were scattered all over the country.

The committee here wishes to express its grateful thanks for the universal kindness and care with which its inquiries have been answered by the various gentlemen whose names will be found quoted as "authority" in the records of experiments (last column). Whatever value this report may prove to possess is due to their assistance.

Necessity for Preserving Timber.

The data on forestry gathered for the census of 1880 have made it apparent that the time has now arrived when railway and other interests must largely resort to the artificial preparation of wood, in many parts of the United States.

As something may be accomplished by economy in the use of timber and by preventing waste, the Washington Convention instructed the

committee to include the latter subject in its report. This was intrusted to Mr. Francis Collingwood, who, from past researches and present inclination, was best fitted for the task, and who has furnished a monograph on the subject, which will be found in Appendix No. 1, and to which particular attention is invited.

From this it appears that our Northern white pine forests, which less than a generation ago were considered as inexhaustible, now bid fair to yield but eleven years more of supply at the existing rate, and that there is a growing scarcity of wood suitable for railroad ties.

These facts must soon produce advancing prices. The farther, but still accessible, supplies are now being drawn upon, and as soon as they are exhausted prices will go up with a jump. Several such periodical advances have already taken place, and in the older States, lumber, timber and ties are ruling at about double the rates prevailing thirty or forty years ago, with a prospect that in less than half that time they will approximate European prices.

Timber has hitherto been so abundant and cheap in the United States that there has been but little inducement or economy in preserving it artificially against decay. It was known that the Europeans, who have been experimenting on the subject for more than a century, had accomplished decided success; but inasmuch as to be effective the work must be well done it was found here to be relatively too costly.

So long as wood was cheap, the cost of efficient preparation, including interest on plant and price of antiseptics, was so great in proportion to the ruling timber prices twenty or thirty years ago that timber preservation did not pay. It was cheaper to let it rot in the good old way, and many corporations and individuals, after trying experiments which were more or less successful, abandoned the work as not conferring benefits commensurate with the cost.

Fresh attention was attracted to the subject by the publication of Messrs. Colburn and Holley's report upon European Railways in 1858. In this very valuable treatise a chapter was devoted to sleepers, and to their preparation against decay. This brought about the erection of some wood-preparing works by the larger railways, and a plentiful crop of so-called inventions to cheapen the processes.

The chief efforts of this crop of inventors were either to discover some cheaper antiseptics, or to use a less quantity than had been found to be requisite in Europe. They also proposed to reduce the time of application. These efforts to produce effects with cheaper agents, or to apply the homeopathic principle of small doses to the preservation of timber, did not meet with success. The inventors patented sundry preparations and methods, took such jobs as they could obtain, sold whatever State and county rights they could, and retired from the field when the insufficiency or danger of their process became apparent. We will hereafter describe some of these processes, and it may fairly be ex-

pected, should the publication of this report lead to renewed attention to the subject of wood preservation, that there will be a new crop of inventions based on the method of "how not to do it."

It will hereafter be seen that some of the processes which have been successful abroad led to indifferent or unsatisfactory results in this country. The committee has endeavored to ascertain the causes of this, and found them in the unobservance of some of the conditions which have been found necessary to success in Europe. These relate to the time occupied in treatment, to the methods pursued, to the strength and quality of the solutions employed, and especially to the fact that the Europeans chiefly operate upon seasoned timber, while we have generally operated upon green or freshly cut timber, which requires a different treatment.

These various points will be touched upon in describing the principal experiments which have been conducted in this country, and will be found fairly to account for whatever differences have been found in the results—differences so great as to have led many managers of important interests to doubt whether any method of wood preparation against decay could be said to be successful.

Preserving Processes.

Although experiments in wood preserving now date back some centuries, and the list of substances experimented with seems nearly endless, * there are but few antiseptics which have stood the test of time, or have been worked commercially.

Special activity seems to have set in with the Railway Era, and the consequent demand for timber which had to be exposed to the weather.

Hundreds of patents were then taken out in England, and the committee has collected 104 issued in the United States. Few of them, however, have proved permanently successful.

Mr. W. P. Moir, in a paper read in 1869 before the Philosophical Society of Glasgow, gives the following list of the names of the patentees and the most valuable compounds employed:

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*In a treatise on the preservation of timber, by Wm. Chapman, Civil Engineer, published in London in 1817, will be found records of experiments with, and mode of application of, the following substances:

Sulphate of iron,	Arsenic,	Mineral coal,
Sulphate of copper,	Barytes,	Charcoal powder,
Nitrate of silver,	Salt,	Coal-tar oil,
Corrosive sublimate,	Quick-lime,	Vegetable oils,
Sulphate of zinc,	Alumine,	Fish oils,
Carbonate of soda,	Selenite,	Essential oils,
Caustic soda,	Soap,	Vapors of oil,
Charring,	Resin,	etc., etc., etc.,

which had been applied to the preservation of timber for ships, jetties, bridges, buildings, etc., etc. This, it will be seen, covers almost all the ground since traveled over by patentees, who are constantly even now experimenting with and patenting substances which had been investigated and discarded by Mr. Chapman and his predecessors.

Kyan	1832	Chloride of mercury.
Margary	1837	Sulphate of copper.
Bethell	1838	Creosote or pitch oil.
Bethell	1848	
Burnett	1838	Chloride of zinc.
Burnett	1840	
Boucherie	1839	Pyrolignite of iron.
Boucherie	1846	Sulphate of copper.
Payne	1841	Sulphate of iron.
Payne	1846	Carbonate of soda.

Concerning the modes of application, Mr. Moir says:

"The methods employed practically in working these patents were three in number, namely: steeping, vital suction and pressing in close vessels; Kyan and Margary employed the first mentioned method; Boucherie employed the second, and Payne, Burnett and Bethell employed the third, which was also latterly adopted by Boucherie. The first and third methods required that the timber should be seasoned and free from sap."

These original patents have now all expired, and the use of the antiseptics which have proved most effective is open to the public. Whatever valuable patents have since been taken out refer chiefly to the modes of application, such as steaming in closed cylinders, to season the wood and remove the sap, and various devices to prevent the antiseptic from washing out upon exposure. Whether it will pay to use them each party will determine for himself, but it may be said in general terms that we now know the antiseptics which are most effective, and that the best modes of application are also pretty well known.

It will much simplify matters, for those who have not made a study of the subject, to group, so far as possible, the records of experience under the names of the best known processes, and to include therein various modifications which had sufficient of novelty to form the basis for a new patent. We have, therefore, classified the various experiments in the United States, concerning which we have been enabled to gather information, under the following heads:

1. Kyanizing—or use of corrosive sublimate.
2. Burnettizing—or use of chloride of zinc.
3. Creosoting—or use of creosote oil.
4. Boucherie—or use of sulphate of copper.
5. Miscellaneous—or use of various substances.

In referring to these experiments, we have endeavored to point out the causes of the success or the failure, and where full information seemed desirable, we give, in the appendix, the text of letters received by us over the names of their respective writers.

Many of these gentlemen took sufficient interest in the matter to hunt up and send to the committee specimens of the timber operated

upon in these experiments. These specimens were exhibited at the National Exposition of Railway Appliances, held in Chicago in June, 1883, and are now deposited in the museum of the Civil Engineers' Club of the University of Illinois, at Champaign, Illinois.

Kyanizing.

As already stated, Kyanizing was first introduced in 1832. It consists in steeping the timber in a solution of corrosive sublimate, probably the most powerful antiseptic known next to creosote.

The original proportions were one pound of the dry salt to four gallons of water, or a solution three per cent. strong by weight. Of this the timber absorbed six or seven pounds of salt per "load" of 50 cubic feet, or say ten to twelve pounds per 1 000 feet, board measure. As the price of this chemical was then $1.25 per pound, it cost some $12 or $14 per 1 000 feet, board measure, and this led to a more sparing use of it. Ultimately the solution was reduced to one pound to ten gallons, or even fifteen gallon of water (1.2 to 0.8 per cent. by weight), and with the latter the timber absorbed about two and a half pounds of the salt per 1 000 feet, board measure.

It was also applied by the "Boucherie" process, but the timber was found to absorb too much of the salt, and some of the solution necessarily ran to waste. The cost induced some of the contractors to further reduce the strength of the solution. To speak in plain terms, it led them to cheating, and Kyanizing fell into contempt in England. Moreover, the process is very tedious, because of the length of time required to impregnate the timber, and there are now but two private establishments in this country (which will be noticed further on) which Kyanize timber for their own use.

As this salt now costs fifty to sixty cents a pound, and as an absorption of four or five pounds per 1 000 feet, board measure, is considered sufficient, Kyanizing now costs about $6 per 1 000 feet, board measure. Where and when it will be profitable to use it will depend upon the price of the timber and its subsequent exposure, and in order to serve as a basis for forming conclusions on this subject we have compiled the table on page 253 of sixteen experiments, which have been made in this country, and we add the comments which they seem to require.

Comments on Kyanizing Experiments.

Concerning the first experiment in the list, General T. J. Cram says, in a report to the Chief of Engineers, made September 9th, 1870:

"I have found our northern red cedar treated with the old Kyan process (an infusion of corrosive sublimate), after 22 years' exposure, lying on a slope of strong limy soil, to have gone to decay, especially the lower ends of the sticks, and Kyanized white oak of Michigan, rest-

RECORD OF SOME AMERICAN EXPERIMENTS.

KYANIZING,

Or use of a solution of chloride of mercury (corrosive sublimate).

No.	LOCALITY.	Year.	Process.	Material Treated.	Subsequent Exposure.	Results.	Authority.
1	Northern Central Railroad	1838	Steeping	Chestnut ties	Railroad track	Favorable to 1849	T. J. Cram.
2	Ft. Ontario, N. Y.	1839	"	Hemlock timber	Fortifications	Partial success	W. P. Judson.
3	Chesapeake and Ohio Railroad	1840	"	Oak ties	Railroad track	Favorable to 1854	H. D. Whitcomb.
4	Alexandria	1840	"	Timber	Bridge	Success to 1862	W. R. Hutton.
5	Delaware and Hudson Canal	1842	"	Rope	Inclined planes	Abandoned	J. Archbald.
6	Baltimore and Ohio Railroad	1842	"	Ties	Railroad track	Not encouraging	J. L. Randolph.
7	Old Colony Railroad	1845	"	"	"	Did not pay	I. Hinckley.
8	Eastern Massachusetts Railroad	1846	Pressure	"	"	Cost too much	H. Bissell.
9	Providence and Worcester Railroad	1847	Steeping	"	"	Did not pay	I. Hinckley.
10	Lowell Canal Company	1848	"	Timber	Bridges	Continued success	J. B. Francis.
11	New York Central Railroad	1849	"	Ties	Railroad track	Favorable to 1859	J. F. Wilkinson.
12	Philadelphia and Reading Railroad	1850	"	Pine timber	Bridges	Success	J. D. Steele.
13	Fitchburg Railroad	1853	"	Joists	Shop floor	Failure	J. Adams.
14	Blackstone Bridge	1854	"	Pine timber	Bridge	Success	W. H. White.
15	Boston and Providence Railroad	1856	"	Ties	Railroad track	Unfavorable	G. F. Folsom.
16	Eastern Massachusetts Railroad	1881	"	"	"	Too recent	H. Bissell.

ing upon the same kind of dirt, dozed and rotted twenty years after the treatment.

"Chestnut railroad ties, grown upon the barrens of Maryland, Kyanized and laid upon a limy soil, some miles north of Baltimore, in 1838, I saw tested 11 years afterward, and then perfectly sound and more solid than when laid; while those of the same kind of wood, untreated but laid at the same time, in the same kind of soil and exposure with the treated ones, lasted only 7 years before they required renewal.

"This experiment of Kyanizing timber was the first, I believe, ever practiced in our country. Ties enough were treated for 1 mile of track, costing 12½ cents per cubic foot of timber. The process, however, was so unhealthy, salivating all the men, it had to be abandoned. It would be worth while to ascertain if those Kyanized ties are yet sound. At that time the untreated ties cost only 14 to 16 cents."

Diligent inquiries among the present officers and some of the former officials of the Northern Central Railroad have failed to elicit any further information as to the final result of this experiment. It is very evident, however, why it was not followed up. Cross-ties usually contain from 2 to 3½ cubic feet of timber, which, at 12½ cents per cubic foot, would make the cost of treatment, at that time, from 25 to 44 cents per tie. This is wholly out of proportion with their original cost, which was 14 to 16 cents apiece. The same ties would now cost untreated about 50 cents apiece, and at the reduced cost of corrosive sublimate could be Kyanized for 15 to 25 cents each.

The records of a similar experiment (No. 3) on the Louisa, now Chesapeake and Ohio Railroad, are furnished by Mr. H. D. Whitcomb. It appears to have been successful up to a certain time, and then to have been lost sight of, probably because the cost of preparation was more than that of the ties.

Experiment No. 2, that at Fort Ontario, has been fully described in the paper of Mr. W. P. Judson, published with our preliminary report. After thoroughly investigating the results, Mr. Judson came to the following conclusions:

"An examination of this work indicates that Kyanized hemlock (and probably Canada white pine also), if set up so that there should be a free circulation of air about it, away from contact with moist earth, and with its bases and joints so formed that water would not lodge in them, would be 80 per cent. sound after 40 years. The use of the process is not recommended for a work which will be liable to continuous moisture."

Mr. Judson, therefore, does not believe that Kyanizing would be satisfactory for railroad ties, in view of the moist nature of their exposure, and his view is confirmed by the results of the experiments on the Baltimore and Ohio Railroad (No. 6) in 1842, on the Old Colony Railroad (No. 7) in 1845, and on the Providence and Worcester (No. 9) in 1847, which were all abandoned as unprofitable.

Concerning experiment No. 15, on the Boston and Providence Railroad, in 1856, Mr. G. F. Folsom, Superintendent of Construction, writes: "The ties were green and half seasoned pine and spruce. After a few years' service the hearts of the ties were found decayed, while ¼ to ½ an inch of the surface was as sound as when laid under the track."

Concerning experiment No. 11, on the New York Central Railroad, Mr. J. F. Wilkinson, of Syracuse, N. Y., says: "In 1849 a quantity of hewed hemlock cross-ties were charged with the solution of corrosive sublimate, I think by immersion in vats prepared for this purpose. In some alterations that were made in the track of the road a large quantity of these ties were taken up after 4 years' use in the main track, and about 2 000 of them were laid in the branch tracks at Oriskany Station. In 1859 I examined the ties in these branches, and found that there was comparatively little decay among them. I do not remember how long it took to prepare these cross-ties. I think that at the time it was estimated to cost about 10 cents each. There were certainly several years added to the duration of the cross-tie."

Mr. J. B. Francis, Past President of this Society, gives Kyanizing preference over other processes; he has been working it with success since 1848 (experiment No. 10), and has furnished the committee the interesting account published in Appendix No. 2.

He informs us that he chiefly uses the timber Kyanized at Lowell for bridges over the canal, and that although he has repeatedly prepared experimental ties for the neighboring railroads, none of them, save the Eastern Railway of Massachusetts, have adopted the process.

For bridges, or for timber exposed to weather alone, and not to constant moisture, there seems to be no question as to the beneficial effects of Kyanizing. This is markedly shown by the record of experiment No. 4, on the Alexandria aqueduct, at Georgetown, D. C., where 9 spans of Burr truss bridge stood from 1840 to 1862, and failed even then, not from decay, but from defects in construction.

It is also shown by the record of experiment No. 14, at the Blackstone River bridge, on the New York and New England Railroad, which consisted of a Pratt truss, built and Kyanized in 1848, and which, although much overstrained by the increased weight of rolling stock, was found, when taken down in 1876, after 28 years of exposure, almost entirely undecayed. Even the foot of the posts, which rested upon oak blocks, were perfectly sound.

A like success attended the Kyanizing, on the Philadelphia and Reading Railroad, of two bridges in 1850 (experiment No. 12), the timber of which remained sound for at least twenty years.

Where, however, timber is exposed to moisture, Kyanizing is of doubtful utility. On the Fitchburg Railroad in 1853 (experiment No. 13), the floor timbers for an engine house at Charlestown were Kyanized, "because the location was very damp." They were found, however, a few

years afterward as much decayed as if they had not been so prepared.

This experience is confirmed by the appearance of a number of Kyanized spruce planks, laid in gate boxes on the Lowell water works, and kindly taken up to send to the committee by Mr. Geo. E. Evans, City Engineer. Where these planks were in dry places, they are quite sound after twelve years' exposure, and the life of the wood has been at least doubled. Where they were in wet places, they are decayed, and the amount of decay seems to be in proportion to the dampness of the situation.

From the foregoing, it seems pretty evident, that for bridges, trestles, fences and similar exposures, Kyanizing is a good process to use, and may safely be relied upon to preserve the wood twenty to thirty years, but that for cross-ties, pavements and work exposed to constant moisture, success is more doubtful, probably in consequence of the washing out of the corrosive sublimate.

There are now two establishments for Kyanizing in the United States. That at Lowell has been referred to in the letter of Mr. J. B. Francis. It consists of two pits or tanks, built of masonry, and lined with wood, each 49 feet long, 7 feet 4 inches wide and 4 feet deep, capable of holding 10 000 feet, b. m., of timber. The sticks are handled in and out by cranes, which also serve to swing large stones that are placed on the wood to prevent it from floating up. It is allowed to steep one day for each inch in thickness of its least dimension, and one or two days in addition. The solution used contains 1 per cent. by weight of corrosive sublimate, and from 4 to 5 pounds of this are absorbed per 1 000 feet, b. m. At a cost of 53 cents a pound, this comes to $2.12 to $2.65 per M., b. m., for chemicals, and as the labor costs about as much more, the total cost may be said to be $5.00 to $6.00 per 1 000 feet, b. m., exclusive of interest on plant and on timber in process of preservation. Some work is done for outside parties, for which $7 per 1 000 is charged, this being supposed to cover a small profit, enough to pay interest on the plant.

The other establishment is on the Eastern Railroad, at Portsmouth, N. H., and an account of this, together with a description of experiments Nos. 8 and 16, will be found in the letter of Mr. H. Bissell, Engineer of Maintenance of Way, in Appendix No. 3.

From this it will be seen that the Eastern Railroad, having resorted to Kyanizing in 1846, by the unusual process of forcing the solution into the wood, in a closed cylinder, subsequently abandoned it, but has taken it up again for the preparation of its ties by the steeping process.

Too short a time has elapsed since 1881 to judge of the results, but the data gathered by your committee indicate that where these ties are laid in dry places (on stone ballast for instance), their life will be materially increased. Where they are laid in wet places, it is doubtful whether the benefit will be commensurate with the cost.

Burnettizing.

The original mode of application employed in Burnettizing was by steeping the timber in a solution of chloride of zinc, in the proportion of 1 pound to every 4 gallons of water. This was found exceedingly tedious, and somewhat ineffective, and Sir Joseph Burnett subsequently adopted Bethell's process (as applied to creosote), of placing the timber in a closed iron cylinder, forming a partial vacuum, to extract the sap, air and water, as far as practicable, and then forcing in the preserving liquid under pressure. This process has since been improved by using steam in the preparatory stage in the cylinder, in order the better to open the pores of the wood to receive the antiseptic, as well as by several devices which will hereafter be described, to prevent the chloride of zinc, which is a very deliquescent salt, from washing out when exposed to moisture.

It is probable that some of the failures which will be described are attributable to the early imperfections in Bethell's mode of application.

On page 258 is a table of the experiments of which the Committee has been able to obtain record.

Comments on Burnettizing.

Burnettizing seems to have been first introduced in this country at Lowell, Mass., in 1850, as stated in the letter of Mr. Francis (Appendix No. 2). It was there worked by the Bethell process till about 1862, when it was abandoned to return to Kyanizing, the latter being thought more effective for bridge and building timber.

In 1855 the Union (horse) Railroad of Cambridge, Mass , was laid with spruce stringers and sleepers, Burnettized at Bangor, Me. The stringers are now (1883) all worn out, but Mr. K. C. Chaffee, the President, writes that "many, and I think the majority, of the sleepers are in good condition to-day," that is to say, after 28 years' exposure.

The experiment seems to have been given up because subsequent lots prepared by contract turned out badly. Mr. Chaffee writes:

"I became satisfied that it could not be got well done (by the contractors). It is of no benefit unless done while the timber is perfectly green, and then well done."

Indeed it may be said once for all that success in timber preservation, by whatever method, depends upon the thoroughness with which the work is done, and that no economy is so false as that which seeks to scrimp the legitimate cost.

In 1856 (experiment No. 3) the Vermont Central R. R. erected Burnettizing works, and prepared large quantities of timber and ties. Some of the latter were found to be nearly sound in 1880, as stated in the letter of Mr. J. W. Hobart, General Superintendent, given herewith in Appendix No. 4.

RECORD OF SOME AMERICAN EXPERIMENTS.

BURNETTIZING,

Impregnating with Chloride of Zinc under Pressure.

No.	LOCALITY.	Year.	Process.	Material Treated.	Subsequent Exposure.	Results.	Authority.
1	Lowell Canal Company	1850	Bethell	Various	Canal work	Unfavorable	J. B. Francis.
2	Cambridge Railroad	1855	"	Spruce ties	Railroad track	Favorable	K. S. Chaffee.
3	Vermont Central Railroad	1856	"	Hemlock ties	"	Success, 1882	J. W. Hobart.
4	Boston Wharf	1857	"	Spruce plank	Wharf	Sound to 1872	C. Page & Co.
5	Middlesex Railroad	1857	"	Spruce stringers	Horse railroad	" "	C. W. Palmer.
6	South Boston Railroad	1857	"	"	"	" "	R. Johnson.
7	Boston and Albany Railroad	1860	"	Spruce ties	Bridge floor	Favorable	E. S. Philbrick.
8	Chicago, Rock Island and Pacific Railroad	1860	"	Timber	Howe truss	Success, 1882	Hugh Riddle.
9	Erie Railway	1861	"	"	Bridges	Unfavorable	W. B. Coffin.
10	Ohio and Mississippi Railroad	1862	"	"	"	Doubtful	T. S. Sedgwick.
11	Philadelphia, Wilmington and Delaware R. R.	1863	"	Ties	Railroad track	Abandoned	I. Hinckley.
12	Chicago, Rock Island and Pacific Railroad	1866	"	"	"	Success	M Alexander.
13	Havre de Grace	1866	"	Timber	Bridge	Strength injured	E Larkin.
14	Philadelphia and Reading Railroad	1867	"	Ties	Railroad track	Hard and brittle	W. Lorenz.
15	Lehigh and Susquehanna Railroad	1867	"	"	"	Success, 1882	L. L. Buck.
16	Union Pacific Railroad	1868	"	Cottonwood	"	Abandoned	L. S. Bent.
17	Long Island Railroad	1868	"	Stringers	Pile bridge	Failure	F. S. Gannon.
18	Philadelphia	1868	"	"	Horse railroad	Unknown	G. S. Gandy.
19	Washington	1872	"	Spruce	Pavement	Failure	J. A. Partridge.
20	"	1872	"	"	Laboratory	Zinc washed out	W. C. Tilden.
21	St. Louis Bridge	1879	Wellhouse	Gum blocks	Pavement	Favorable, 1883	C. S. Smith.
22	"	1879	"	Pine stringers	Bridges	" "	"
23	St. Louis, Iron Mountain and Southern R. R.	1879	"	Ties	Railroad track	" "	H. Constable.
24	Illinois and St. Louis Railroad	1880	"	"	"	" "	C. H. Sharman.
25	Atchison, Topeka and Santa Fé Railroad	1881	"	"	"	" "	A. A. Robinson.
26	St. Louis	1879	"	Gum blocks	Pavements	" "	H. Constable.
27	Norfolk, Va	1880	Thilmany	Pine piles	Teredo	Failure	P. C. Asserson.
28	Chicago and Alton Railroad	1880	"	Ties	Railroad track	Too recent	W. F. Merrill.
29	Erie Railway	1882	"	"	"	"	O. Chanute.
30	St. Louis	1883	Zinc gypsum	"	"	"	T. Plate.

The process seems to have been given up after four years' use, in consequence of the delays and annoyances involved in treating such large quantities of timber as are used on a railroad, only to find out after a lapse of 25 years what a great success it had been.

Experiments Nos. 4, 5 and 6 show that some spruce plank and track stringers, Burnettized in 1857, and laid on a wharf in Boston, and on some horse railroad, were yet sound when examined in 1872, or some 15 years afterward. We have not been able to trace their subsequent history.

In 1860 (experiment No. 8) the Chicago, Rock Island and Pacific R. R. built a Howe truss bridge of 8 spans of 150 feet each, which was still in use and in fair condition in 1882, as stated in the letter of Mr. Hugh Riddle, its President, published in our Preliminary Report.

In 1860 some Burnettized spruce ties were placed in the floor of an iron bridge built by the Boston and Albany R. R., in the City of Boston. They lasted 9 years, and were replaced by untreated white pine, which only lasted 5 or 6 years, when chestnut ties, unprepared, were substituted, which have lasted seven years, and were replaced last season by a second set of chestnut ties, also unprepared.

A full account of this experiment (No. 7) will be found in the letter or Mr. E. S. Philbrick, published herewith as Appendix No. 5.

It will be noticed therefrom that the Burnettizing doubled the life of the spruce, which would otherwise have lasted but 4 or 5 years, and that the ties finally failed by checking and splitting, so as no longer to hold the spikes. Exposure as bridge ties seems particularly liable to bring about this result, and Mr. Philbrick's experience leads him to believe that Burnettizing is of more avail where timber is covered with earth than when fully exposed to sun and air. This opinion is confirmed by the statement of Mr. Hobart (Appendix No. 4), who found Burnettized ties nearly sound after having laid some 25 years in an old side track, nearly covered with earth and grass, and this probably results from the less opportunity for the washing out of the chloride of zinc from the timber by the action of rains.

In 1861 (Experiment No. 9) the Erie Railway built a set of Burnettizing works at its bridge shop at Owego, New York. These works chiefly consisted of an iron cylinder 70 feet long and 6 feet in diameter, with a heavy iron door at each end, and a track running through it, on which the material was run in on small trucks, moved by a hand-power windlass. The capacity was 13 000 feet, b. m., and the Bethell process was used.

When the cylinder was filled and the rubber-packed doors closed, a powerful air-pump was applied, and as perfect a vacuum formed as possible, and maintained one hour, to withdraw the sap and air from the timber. A stop-cock was then opened in the pipe connecting the cylinder with the tank containing diluted chloride of zinc, and the liquor

admitted. When the cylinder was filled, the stop-cock was closed, and a powerful force-pump set at work, which forced the solution into the cylinder under a pressure of 120 to 150 pounds per square inch. This pressure was maintained about four hours, and left sometimes in over night, when the timber was taken out.

The strength of the solution was about 2 or 3 per cent., and with labor at $1.50 per day, the cost of the treatment is said to have been from $1.50 to $2.50 per 1 000 feet, b. m.

The treatment was applied almost entirely to bridge timber and plank for platforms, crossings, etc. Very few cross-ties were prepared, and only as an experiment.

The results were not entirely satisfactory, and when the works burned down in 1869 they were not rebuilt. Two-inch plank seemed to be well preserved, but large timber, taken out of bridges 8 or 9 years after treatment, showed a hard crust from ¼ to 1 inch thick all round, but was rotten at the center, thus tending to deceive the bridge inspectors as to the soundness of bridges which might really be insecure.

Some pains have been taken to ascertain the causes of this want of success. They seem to have been as follows:

1. Original imperfections in the "Bethell" process. The partial vacuum did not properly clear the timber of sap. This has since been improved upon by previously steaming the timber, to liquefy and vaporize the sap, before the vacuum is applied.

2. It was probably a mistake to select bridge timber for this experiment; imperfectly as the work was done, it would have proved a far greater success if it had been applied to cross-ties.

3. Operating upon unseasoned timber. As practiced in Europe, Burnettizing is exclusively applied to seasoned timber. This being generally imported from a distance, has a chance to dry in transit; or if cut in the vicinity of the works, it is piled up for several months before treatment, or is thoroughly steamed, so that the water may evaporate and make room for the solution. Moreover, it is also well dried before using, to prevent the zinc from washing out. As a confirmation of this view, it may be mentioned that while the bridge timber did not last well, several sets of switch ties which had been cut about 8 months, and seasoned, were Burnettized at Owego, for the road department of the Erie Railway, and laid in its tracks, with the result that nine years afterward they did not show a particle of decay. These ties have been lost sight of since, but your committee has in its possession an oak tie, one of a lot of two car loads, seasoned and Burnettized at Owego, which lay in the track at Susquehanna station for 17 years, and is almost perfectly sound to-day.

4. Insufficient pressure. It has been suggested that the pressure ought to have been some 200 pounds per square inch, and continued 8

hours instead of 4. This might have produced somewhat better results, but it is believed that the last cause, which remains to be mentioned, more fully accounts for the partial want of success.

5. Undue haste in the treatment. In accordance with the usual railroad practice of never ordering materials until they are imperatively required, the timber was not procured until the bridge which it was intended to rebuild was about ready to come down. Then there was great haste; the Burnettizing works were hurried up, and the timber went straight from the stump into the cylinder, and from that into the bridge, with very imperfect treatment. The pressure was applied to the operatives, instead of to the cylinder, and as a result the timber was "put through," without sufficient preparation, some of it hard frozen in winter.

Mr. Jas. D. Bishop, formerly Superintendent of Bridges of the Erie Railway, who had charge of these Burnettizing works, writes: "All the timber used in renewals of bridges, and exposed parts of buildings, platforms, etc., upon the road, which was a very large amount, was hurried through this process, and for the want of time was done quite imperfectly. I consider the process of Burnettizing timber a success, in preserving the same to at least 50 per cent. beyond its natural life, if the Burnettizing is well done."

Mr. H. D. V. Pratt, formerly General Superintendent of the Erie Railway, writes:

"The timber used in bridges, that was Burnettized in the winter, was full of frost, and Burnettizing had no other effect than to confine the sap, and make the timber decay much sooner than it otherwise would have done."

Under these circumstances, it seems to be no wonder that the results were not entirely satisfactory, but all this amounts to saying a very simple and very obvious thing—that we cannot hope to get a preservative solution into the timber unless we first contrive to make a place for it, and that in order to be successful, the work must be done skillfully and thoroughly.

For this there must be no undue haste; but at the same time it must be acknowledged that the delays required properly to season and to prepare timber and ties are particularly exasperating to railroad men, and many of the works and experiments which have heretofore been abandoned have doubtless been given up because of the delays which they brought about in necessary renewals of bridges and of roadway.

The above information has been furnished in large part by Mr. W. B. Coffin, Superintendent of the western division of the Erie Railway, and it should be stated in fairness that Mr. J. D. Bishop (who had charge of the works, and to whom this statement of the experiment has been submitted) writes that we "have put it rather too strongly as to its not being a success."

Now that the Bethell process has been improved by a preliminary steaming to season the timber, there seems to be no reason to doubt that the work can be well done at all seasons.

We may here refer to experiment No. 16, on the Union Pacific R. R. Burnettizing works were erected at Omaha by that company in 1867–8, and run about one year on cottonwood ties. The cost of treatment is stated to have been about 30 cents a tie.

The works were abandoned as impracticable, as not one-tenth of the ties used could be put through the machine. Some difficulty was also found from the brittleness of the prepared ties, probably, as will be explained hereafter, from the use of too strong a solution in order to hasten the process.

It is doubted by your committee whether it is wise to attempt to prepare artificially (by any process) ties for a road in process of rapid construction. The quantities required are too vast, and delays are too annoying. It is clear that if it is desired to lay some 3 miles of track a day, requiring about 8 000 ties, works consisting of one or two cylinders, the capacity of which are from 500 to 1 000 ties a day, will not be sufficient. The remedy is to provide an adequate plant, but this would be costly.

This difficulty disappears for roads in process of operation, and then it becomes quite practicable with one set of works to prepare the ties needed for renewals within a certain district.

Experiment No. 11, on the Philadelphia, Wilmington and Baltimore R. R., and experiment No. 14, on the Philadelphia and Reading R. R., are instructive, and at first puzzled your committee not a little. These companies set up their own works and Burnettized their own ties in order to have the work well done, and they overdid it.

They found the ties would last against decay, but that they broke in the track. As Mr. I. Hinckley, the President of the P., W. and B. R. R. expresses it, "they were as brittle as a carrot," and would break in unloading from a car. As Mr. Lorenz, the Chief Engineer of the Philadelphia and Reading R. R. puts it, "the elasticity and strength of the wood was destroyed. The ties became too solid for good wear of the rails," and many of them were removed from the track and used as fence posts, where they lasted a long time.

The explanation is that the solution was too strong, and the surplus zinc probably crystallized in the sap ducts of the timber, burst some of them asunder, and so made the wood brittle. On the P., W. and B. R. R., a saturated solution was used, probably 5 or 6 per cent. strong, and on the Philadelphia and Reading R. R. the solution was 3¾ per cent. strong, while experience in Germany has thoroughly established the fact that for railroad ties the solution should not be over 2 per cent. strong, and 1.91 per cent. is considered the standard.

In this connection we refer you to Appendix No. 6, which consists of

an account of German experience with preserved railroad ties, written by Privy Councillor Funk, of the Cologne and Minden R. R., and translated for the "Railroad Gazette" of May 28, 1880. It will be found very interesting and instructive, and we may here quote the two conclusions which seem most important to us.

"No. 2. The average life of ties properly impregnated with creosote or chloride of zinc, under a powerful pressure, reaches:

For oak	ties.....	19. 5 years.
" fir	" (hemlock?)	14 to 16 "
" pine	"	8 " 10 "
" beech	"	15 " 18 "

"No. 7. The results of impregnation with chloride of zinc and creosote are about equal. But as the impregnation with creosote costs about three times as much as with chloride of zinc, a majority of the German railroads have gone over to the latter."

Experiment No. 12, on the Chicago, Rock Island and Pacific, in 1866, confirms the German experience. About 75 per cent. of Burnettized hemlock ties were still in the track in 1882, after 16 years of exposure, as stated in the letter of Mr. M. Alexander, roadmaster, given as appendix No. 7.

A similar result was obtained in experiment No. 15, on the Lehigh and Susquehanna R. R., where Mr. L. L. Buck, whose letter is given in Appendix No. 8, found that maple, beech and hemlock ties had resisted decay almost perfectly with 15 or 16 years' exposure.

Concerning experiments Nos. 10, 17, 18 and 19, we have been able to obtain but little information. They seem to have been failures, but whether due to bad work or to the exposure we could not find out.

We may say, however, that we consider Burnettizing less well adapted to bridge work than to the preservation of ties. This is indicated by the results of experiment No. 13, at the Havre de Grace bridge, where pine timber Burnettized proved brittle. Mr. Edward Larkin, who had charge of this bridge, and whose letter we give in Appendix No. 9, states that the solution was $1\frac{1}{100}$ per cent. strong. We are inclined to believe that it must frequently have been exceeded in working, as a solution of this strength has nowhere else (that we know of) proved injurious to the strength of the timber.

It has been found, however, both in this country and in Europe, that when zinc solutions are employed, weak enough not to injure the strength of the timber, they are likely to wash out under the action of rains and moisture, and to leave the timber unprotected. This is quite well shown by the ties on the Chicago, Rock Island and Pacific Railroad (experiment No. 8), which are decayed and exfoliated on the outside.

Burnettized ties decay from the outside toward the heart, while creosoted ties are more likely to decay from the heart outward. The

reason is the same in both cases, decay beginning at the point where there remains the least of the antiseptic material. The heart-wood being most dense, naturally absorbs the least; but in the case of Burnettizing, the chloride of zinc being a very deliquescent salt, readily washes out and allows decay to set in. Creosote or dead oil does not work out, and, in time, decay begins in the heart-wood which has received the least of it.

When wooden pavements began to be largely used in Washington, D. C. (experiment No. 19, which, by the way, seems to have failed because of very bad work), Mr. W. C. Tilden, A. A. Surgeon, U. S. A., made some chemical tests on the various processes of wood preserving which were used or proposed. In the case of Burnettized spruce (experiment No. 20), he found that all the zinc was easily removed by acidulated water, and this defect in Burnettizing seems to be so generally understood that it has led to the patenting of a number of devices to remedy it.

The first of these in point of date is that of Mr. W. Thilmany, who patented the use of a double solution, the first being that of sulphate of zinc, and the second, subsequently applied, a solution of chloride of barium, which, it is claimed, by combination with the first solution, changes it into an insoluble salt of sulphate of baryta. Experiments Nos. 27, 28 and 29 pertain to this process, and time will have to determine whether they prove successful. Chemists who have been consulted by your committee doubt whether it is possible for this chemical reaction to take place on the inside of the sap-ducts of the wood, many of which are only 1-200 of an inch in diameter.

The next patented process was that of Mr. Wellhouse, who also employs a double solution, the first being chloride of zinc, to which a little glue is added, and the second a solution of tannin, which it is claimed forms, upon coming into contact with the glue, small pellicles or films of insoluble artificial leather, which plug up the mouths of the sap-ducts, so as to prevent the zinc from washing out. Experiments Nos. 21, 22, 23, 24, 25 and 26 pertain to this process, and the results seem thus far to be favorable.

The last patented process which seems to call for mention is that of Mr. Hagen, who uses but one solution consisting of chloride of zinc and gypsum. It is claimed that the gypsum (sulphate of lime) crystallizes and hardens inside of the sap-ducts, and thus forms partitions to hold the chloride of zinc within the cells. Experiment No. 30 represents this method, and the process is now on its trial.

There are now three Burnettizing works in this country. One at Defiance, O., operates the Thilmany process. An account of the latter is given in Appendix No. 10, by Mr. O. Thilmany, the proprietor.

Works at St. Louis operate the Wellhouse process, of which an account is given in Appendix No. 11, by Mr. J. P. Card, President,

while still other works at St. Louis are operating the zinc-gypsum process, of which an account is given in Appendix No. 12, by Mr. Theo. Plate, President.

The cost of Burnettizing, when well done, is about five dollars per 1,000 feet, b. m., or twenty to twenty-five cents a tie. It is particularly adapted to the latter purpose, and your committee recommend it as the available process to use (in view of the cost) for the preservation of railroad ties. It is believed to be less well adapted to bridge or trestle work, but for wooden pavements, if well done, it will probably prove a success.

It cannot be too strongly insisted upon that the work must be well done. The sap or moisture must be removed from the wood to make sufficient room for the antiseptic, and a sufficient amount of the latter must be put in. To do this thoroughly, of course, costs more than to do it hurriedly and badly. It will be noticed in Appendix No. 6 that the cost of Burnettizing has ranged from 5.8 to 19.2 cents a tie in Germany. It has been done for 15 cents a tie in this country, but is said to have cost about 25 cents a tie on the P., W. & B. R. R., and some 35 cents a tie on the Philadelphia and Reading Railroad, where, however, there was an unusual amount of handling.

Creosoting.

This process consists in injecting the timber with hot creosote oil in a closed cylinder under pressure. It was invented and brought into use in 1838 by Mr. John Bethell, of England; and in 1853, in a discussion of a paper (by Mr. H. P. Burt) before the British Institution of Civil Engineers, he made the following among other remarks:

"Experiment proved that oil of tar, or creosote, was perhaps the most powerful coagulator of the albumen (of wood), while it, at the same time, furnished a water-proof covering for the fiber, and its antiseptic properties prevented putrefaction. If, then, the operation of injection was well performed, there was every reason to anticipate the perfect success of the system. He found that by forcing at least 7 pounds of creosote oil into each cubic foot of timber the process was perfect for railway work, but for marine work it was better not to have less than 10 pounds per cubic foot.

"He was inclined to prefer the employment of porous timber, as it absorbed the creosote more readily, was more perfectly saturated, was cheaper in first cost, and, when properly prepared, would last longer than heart of oak or any other very solid timber." * * * * *

"The best timber for use was young, growing wood, *thoroughly dried;* if it was fresh cut, or had been floated so as to saturate the pores with water, there was great difficulty in creosoting it." * * * * *

"He had experienced so much difficulty in procuring a proper qual-

ity of oil of tar that he was compelled to establish manufactories and to distil it to suit his own purposes."

The best known engineers, such as Messrs. Brunel, Hawkshaw, Rendell and others, also gave, on that occasion, the results of their experience, which was in every case satisfactory when the work was thoroughly done, and creosoting has now become the standard mode of timber preparation in England.

There is no question about its efficacy and economy when well done, as evidenced by the fact that out of 12 of the leading railways of Great Britain to whom Mr. Bogart, Secretary of this Society, addressed circulars of inquiry in 1878, 10 used creosoted sleepers, and some of them forwarded with their answers sleepers taken from their tracks, which were yet sound and in use after 22 years of exposure.

As a protection against marine worms (the *Teredo Navalis* and *Limnoria Terebrans*) creosote is the only known preservative, and if there be enough of it injected it is thoroughly efficient. All other substances which have been tried have failed, but the success of creosote has been established by abundant evidence all the world over.

The English have found 10 or 12 pounds to the cubic foot sufficient in their harbors. The Dutch and Belgian engineers use about the same. But the French, relying upon a series of very careful experiments, extending over a series of years, made by Mr. A. Forestier, consider that about 19 pounds to the cubic foot is required in their harbors in order to be quite safe against the *teredo*. This latter quantity has been used in this country by Mr. J. W. Putnam for piles exposed along the Gulf of Mexico, and it seems probable that the higher temperature of the sea water, and consequent greater activity of the *teredo* in the French and our own southern harbors, requires a more thorough impregnation with creosote than in northerly waters to afford immunity.

The conditions under which creosoting is done in England differ from those in this country in two important particulars:

1. The English operate upon *seasoned* timber, which, as it is chiefly brought from the islands of the Baltic, from Norway and from Sweden, generally reaches them some 5 or 6 months after it is cut, and frequently remains stacked up some months more after arrival before it is creosoted. All the English engineers specify that "the timber shall be thoroughly dry before being creosoted," while in this country we have almost invariably operated upon freshly cut timber, full of moisture and sap.

This has led to steaming the timber previous to its injection with creosote (as well as with the metallic salts), in order to vaporize the moisture and make room for the solution. There are several methods of effecting this steaming, covered by a number of patents more or less meritorious, but the committee has included them under the general head of steaming in describing some American experiments.

It is understood that steaming is now also used abroad, particularly

in Germany, even when seasoned timber is injected, it being considered a valuable improvement upon the original process of Mr. Bethell.

2. Creosote is cheap and abundant in England, while it is comparatively scarce and dear in this country. This, together with the higher price of labor and the longer time required to operate upon freshly cut timber, has made creosoting so much more expensive here than in England that in a majority of cases calculation showed that it was cheaper to let the timber rot and to replace it than to go to the expense of preparing it against decay.

This condition of affairs brought about a considerable number of inventions and experiments to circumvent the foreign experience and to make a little creosote perform as much as a great deal. None of these can be said to have been successful, and it is one of the anomalies which at first much puzzled your committee that the record of creosoting experience in this country should chiefly consist of failures, while the process is a thorough success in England.

Investigation showed, however, that most of these experiments were not true creosoting, as understood abroad, and, inasmuch as failures are far more instructive than successes, they are here given, under the general head of "Creosoting," while our comments will show wherein they differ from true creosoting.

Comments on Creosoting Experiments.

The first experiment upon the list, that on the Philadelphia and Reading Railroad in 1854, was not made with creosote at all, but with the coal tar from which it is extracted. "Some 70 000 ties were prepared by first placing them in a large drying chamber for 76 hours, at a temperature of 120 degrees, then placing them for 2 hours in a bath of coal tar, at a temperature of 150 degrees." Subsequently this was changed to the dipping of 2 feet at each end of the tie into the tar, so as to give the center a chance to part with any remaining moisture.

The cost was 8 cents a tie, but it was discontinued, because it was not found to prolong their life.

The Committee has heard, in a somewhat vague way, of a good many other experiments with coal tar. None of them proved successful, except where seasoned fence posts or paving blocks had their lower ends dipped. This kept out the ground moisture, while the wood could still dry out through the top. Whenever the whole stick was covered with coal tar, and the sap and moisture confined, the result was fermentation and failure, especially in those cases when the ammonia was not previously removed from the tar by boiling.

The second experiment (in 1865) was true creosoting. It was conducted under the instructions of Isaac Hinckley, Esq., then of Massachusetts, in the preparation of about 700 piles for the construction of a bridge over the Taunton River, on the Old Colony Railroad. Creo-

RECORD OF AMERICAN EXPERIENCE—CREOSOTING.

No.	Locality.	Year.	Process.	Material Treated.	Subsequent Exposure.	Results.	Authority.
1	Philadelphia and Reading Railroad	1854	Coal tar	Ties	Railroad track	Failure	W. Lorenz.
2	Taunton, Mass	1865	Bethell	Piles	Teredo	Favorable	I. Hinckley.
3	Callowhill Bridge	1868	Boiling	Plank	Bridge floor	Failure	R. Hering.
4	Chicago, Burlington and Quincy R. R.	"	Seely	Ties	Railroad track	Failure	T. H. Perry.
5	Chicago, Rock Island and Pacific R. R.	"	"	"	"	Failure	E. H. Johnson.
6	St. Clair Flats	"	"	Pine timber	Canal	Failure	F. Harwood.
7	Wilmington, Cal	1871	Robbins	Piles	Teredo	Failure	C. B. Sears.
8	Washington	1872	"	Paving blocks	Laboratory	Unfavorable	W. C. Tilden.
9	"	"	Seely	"	"	Favorable	"
10	Pittsburgh	"	"	"	Street	"	A. Dempster.
11	Washington	"	Constant & Smith	"	Laboratory	Unfavorable	W. C. Tilden.
12	"	"	Detwiler	"	"	"	"
13	"	"	Thomas	"	"	"	"
14	New Orleans	"	Boiling	"	Paving	Success	T. Forstall.
15	East River Bridge	"	Steaming	Plank	Caisson	Success	F. Collingwood
16	Boston	"	"	"	Floor	Success	Blake Mfg. Co.
17	Cleveland	1873	Seely	Blocks	Paving	Favorable	H. G. Wilson.
18	U. S. S. Vandalia	"	Steaming	Timber	Ship	Favorable	F. L. Fernald
19	Dry Tortugas	"	"	Gun platforms	Fortification	Failure	W. H. Hener.
20	Titusville	"	Petroleum	Ties	Railroad track	Various	O. Chanute
21	Rochester	"	"	Machines	Weather	Favorable	J. M. Harris.
22	Galveston	1874	Steaming	Pine blocks	Paving	Failure	G. M. Hartwick.
23	"	"	"	"	Stable	Success	W. E. Gregory.
24	"	1875	"	Piles	Teredo	Partial success	B. M. Temple.
25	New Orleans and Mobile R. R.	1876	"	"	"	Success	J. W. Putnam.
26	" "	"	"	Timber	Bridges	"	"
27	Bound Brook Railroad	"	Hayford	Ties	Railroad track	"	E. R. Andrews.
28	New York	"	Webb's	"	"	Failure	
29	Delaware Bay	1878	Steaming	Pine blocks	Teredo	Success	W. Ludlow.
30	Philadelphia and Reading Railroad	"	"	Ties	Railroad track	Success, 1882	W. Lorenz.
31	Boston	"	"	Fence posts	In earth	Favorable	A. F. Perkins.
32	Hoboken	"	"	Ties	Railroad track	"	W. W. Shippen.
33	"	1879	"	Piles	Teredo	"	"
34	Trenton	"	"	Planks	Bridge	Favorable	R. E. Pettit.
35	New Orleans	1880	"	Ties	Railroad track	"	T. Forstall.
36	Houston	"	"	"	"	"	M. G. Howe.
37	New Orleans	1882	"	Piles	Bridge	"	G. Bouscaren.
38	Charleston, S. C.	"	"	"	Wharf	"	J. W. Putnam.
39	Pensacola and Atlantic R. R.	"	"	" and timber	Bridges	"	"

soting works were erected for the purpose of treating these piles, and these works are still in use at Somerset, Mass. In 1878 the Chief Engineer of the Old Colony Railroad, the late E. N. Winslow, wrote as follows about these piles :

"We have removed about 200 of the 700. * * * The work was generally done with a rush and in a careless manner; many of the piles were fitted, knots trimmed up, etc., after they were creosoted. I find they are eaten in patches and spots, commencing apparently where the trimming was done. Upon examination I find the outer portion of the piles from ¼ to ½ inch in thickness, filled with creosote, to-day as limpid and odorous as when applied. Hence, I infer the attack has been made in almost every instance where the trimming or fitting was done."

The experiment was considered a success, and has been continued, but all trimming of timber after treatment, destined to be exposed to sea water, is now recognized, both here and abroad, as fatal to success, inasmuch as the *teredo* will attack any point unprotected by sufficient creosote, and will speedily make his way to the heart wood, which, in consequence of its density, can absorb but a small portion of this preservative.

The third experiment was simply an instance "how not to do it." Instead of being properly creosoted, the planks for the Callowhill bridge floor, in Philadelphia, were simply dipped into hot creosote, absorbed but a small portion of it, and decayed quite as fast as if they had not been treated at all.

Even the framing of creosoted timber which is to be exposed to sun, air and rain, is considered undesirable, as the cutting away of the saturated part admits the germs of decay to the less impregnated parts.

Experiments 4, 5 and 6 pertain to the Seely process, which was hailed at first as a great improvement over the methods pursued in the "effete countries of Europe."

The process consisted in immersing the wood in a closed iron tank of the oil, and raising the temperature to between 212 and 300° F. This was supposed to drive all the moisture out of the wood, when the hot oil was suddenly replaced by a bath of cold oil, which, condensing the steam remaining in the sap cells, was supposed to rush in and saturate the timber thoroughly.

It was believed to be well adapted to operating upon green, wet or unseasoned timber, and as the wood generally absorbed but 2 to 4 pounds of creosote to the cubic foot, it could be treated at about European prices. The process was vigorously pushed for a time, and introduced in all parts of the country. It failed on the Chicago, Burlington and Quincy Railroad (No. 4), on the Chicago, Rock Island and Pacific (No. 5), and on the Government works at the St. Clair Flats (No. 6).

It was possible, however, with sufficient time and expense, to obtain with this process better results than the above. A specimen paving

block (experiment No. 9), submitted to the Government chemist, Mr. W. C. Tilden, in 1872, presented a satisfactory appearance of saturation, and paving blocks in Pittsburg (experiment No. 10), as well as in Cleveland (experiment No. 13), having been saturated with about 4 pounds of creosote to the cubic foot, have lasted about 10 years, or some 4 or 5 years longer than they would have lasted in their natural state.

There were those, however, who believed that the Seely process used too much creosote, and who reasoned that if dead oil were applied to the timber in the shape of vapor, it would be much more penetrating, and a much smaller quantity would answer.

A number of devices were accordingly patented for smoking wood with the vapors of coal tar and of creosote. Of these, the process which became the best known was that of Mr. L. S. Robbins, which was first introduced in 1867.

It was most extensively advertised. Local companies were formed in New York, New Jersey, Pennsylvania, Massachusetts, New Hampshire, Connecticut and California, with millions of capital. A convention of delegates from each of these companies was held at the Astor House, in New York, in 1869, at which Mr. Robbins was spoken of as a "great public benefactor," whose "American genius has made an invention which may be classed among the greatest achievements in the useful arts, whose process accomplishes by the subtle agency of vapor, in a perfect manner, what the Bethell process, by the gross material, imperfectly did. The Bethell process, however, established the efficacy of coal tar treatment to preserve wood from decay, but how much more certainly will decay be prevented by the Robbins process?"

The first record we have of the results is that of experiment No. 7, in the Government harbor works, at Wilmington, Cal., in 1871. Over a million feet of timber was treated by the Robbins process, being impregnated with about 1¼ pounds of oil to the cubic foot, at a cost of $10 coin per 1 000 feet, b. m. The engineer in charge, Mr. C. B. Sears, says:

"It utterly failed to protect the timber from the worms, which were not more than two months longer in attacking it than in attacking the untreated timber, and when once in, their action seemed to be more rapid and destructive than in the latter; in fact they relished it rather more."

But if the Robbins process was held in contempt by the *teredo navalis*, it was claimed that it was efficacious in preserving against decay "wooden pavements, railroad ties, telegraph poles, freight cars and coffins." It was examined for the first of these purposes (experiment No. 8), by Mr. Tilden, who reported:

"Absorption power very high. Percentage of hydro-carbons very low in all portions of block, except the outer. No solid hydro-carbons observed, even on surface (naphtalin, etc). Condition of wood shows injury from heat. Specimens are evidently suited for exposure *to dry air* only, under which circumstances the protection is sufficient."

To make a long story short, the process entirely failed to perform what was claimed for it; some portion of the works which were in New Jersey blew up, and the enterprise also exploded. Somewhat similar was the process of Constant and Smith (experiment No. 11), which provided an iron chamber in which the wood was placed and exposed to the smoky vapors of coal tar, generated in a separate retort. It did no good in preserving timber.

The same may be said of the Detwiler and Van Gilder process (experiment No. 12), of impregnating wood by resin dissolved in naphtha under pressure and at a high temperature.

In 1871, Mr. N. H. Thomas, of New Orleans, brought forward a proposal for preserving wood by immersing it in rosin oil. The process was thus described by the consulting chemist:

"The albuminous matters of the wood are coagulated, and the sap converted into steam by heat, and the wood thus treated is plunged into boiling rosin oil. The rosin oil permeates the pores of the wood, and not only prevents the introduction of moisture and oxygen, but it also, in virtue of it own indestructible and antiseptic properties (similar in most cases to those possessed by the materials used by the Egyptians in embalming dead bodies, and which has resisted decomposition for ages), preserves the wood from decay, and the destructive action of plants and animals."

After figuring up the enormous money savings which would result to various interests, *if* timber can be made to last by his process "25 or even 20 years," Mr. Thomas thus summed up the history and mystery of wood preservation: "Kyan invented a process of preserving wood in 1832; Burnett, in 1838; Bethell, in 1838; Margary, in 1837; Boucherie, in 1839; Payne, in 1841. Thomas patented his invention in 1871, after many years of experiments. Chloride of mercury, sulphate of copper, creosote, chloride of zinc, pyrolignite of iron, sulphate of iron, carbonate of soda are the materials used by the first-named inventors. Thomas uses rosin oil, which is cheap and healthy."

Works were erected in New Orleans, but after several years of experiments, it was found impracticable to impregnate wood with enough rosin oil to do any good, the difficulty being understood to be that it could not be rendered sufficiently fluid to fill the sap cells so as to prevent the intrusion of moisture. The enterprise was accordingly given up.

A somewhat singular proposal was that of the "American Wood Preserving Company," of the city of New York, which we have not included in our list of experiments, because we have not been able to learn that it ever tried any experiments.

In 1868 it issued a circular beginning as follows:

"By ancients, we have to say, that centuries ago, when the banks of the Nile became so densely populated, and the forests of Northern Africa disappeared and were converted to the uses of civilization, it be-

came necessary to adopt some means to preserve all articles that were composed of wood from mold or decay. Wood became valuable; the demand for it was imperative. How long it required to bring the processes of preservation to perfection, it is now impossible to find out; but that the Egyptians had a process, and that they did preserve wood and many other perishable things for thousands of years, there is no doubt."

"In the New York Historical Society rooms, corner Second avenue and Eleventh street, which contains the Egyptian Museum, can be seen *wood which is over four thousand years old;* also linen, towels, robes, ropes, canvas, paper, and numerous household articles and implements, all of which have been preserved and are now in good condition, so that, whatever may be said as to what can or cannot be done in this age, we have the incontrovertible fact before us that wood *has been* preserved *for over forty centuries.*" * * * * * "To rediscover the lost arts of the ancients has for years occupied the attention of the first minds of the old world; but it seems to have been reserved for *this inventor* to discover and apply practically one of the most important." * * * * "It will give us great pleasure to have you call at our office at your convenience, when we can undoubtedly satisfy you as to the merits of this great invention. We would very much like you to become interested in the enterprise, as we have no doubt it will prove a great success."

No explanation whatever was given in this circular as to the character of the process; but having indicated the exact museum where the Egyptian remains were to be found, and hinted that the inventor had rediscovered the method of their preservation, the public was invited to subscribe for shares in a company with a "capital stock of $1 000 000, divided into 10 000 shares of $100 each, of which 1 000 shares reserved for a working capital."

The process (which is believed by the committee to have been some method of applying rosin) does not yet seem to have come into general use.

Nothing is more curious than the way in which all the inventors of cheap processes for preserving wood quote the ancient Egyptians. That bodies, coffins and cloths should have been preserved for three or four thousand years appeals to their imagination; and, taking no account of the fact that the Egyptian mummies were kept in perfectly dry caverns, thoroughly protected from weather and moisture, they are sure to claim that their particular nostrum had something to do with it.

They claim this for the "Seely process" of employing creosote; for the "Robbins method" of using coal tar; for the "Thomas application" of resin; for the "Foreman process" of applying arsenic, etc., etc. And then they generally go to work figuring up the profits, much after the method of Col. Sellers of multiplying the profit on a bottle of eye water by the number of sore eyes in the world.

While on this subject we may allude to a New York inventor who did not "spoil the Egyptians," but tried instead an entirely original experiment. Having noticed that the scows which he used in his business were attacked by the *teredo*, he smeared their bottoms and sides with hot coal tar, and then sprinkled over it an even layer of *Scotch snuff*. Being a hater of tobacco, he believed this would be about the most disagreeable thing he could do to the *teredo*. Unfortunately, however, for the experiment, the coal tar rubbed off in spots, and the *teredo* got in.

Experiment No. 14 was tried in New Orleans in 1872. Cypress paving blocks were thoroughly boiled in creosote, or dead oil, in the still of Geo. H. Fletcher, and were laid in the yard of the New Orleans Gas Light Company. They are said to have been saturated with not less than 20 pounds, and probably with 25 to 30 pounds, of dead oil to the cubic foot, and are now (1885), after 13 years' exposure, as sound and perfect as when first laid.

Experiment No. 15 was only a temporary expedient to protect the sheathing of the East River Bridge caisson from the *teredo* while being sunk. Being now entirely buried beneath the mud, it is safe from attack. Only 2 pounds were injected per cubic foot.

Experiment No. 16 consisted of some planks, creosoted by the Hayford process, laid in 1872 in the basement floor of the factory of the Blake Manufacturing Company. These were yet in an unusually good state of preservation in 1882, although having been in contact with the flow of the tide since they were put down.

Experiment No. 18 was tried by the United States government upon the U. S. steamer "Vandalia." This vessel was built in 1873, of timber creosoted by the Hayford process, and when examined in 1882 was quite sound, while other ships built at the same time of untreated timber had received and still required extensive repairs. There seems to be no question that when creosoting is well done it is effective.

There must have been some careless work in experiment No. 19, in which some 12″ by 14″ timbers for gun platforms were treated at Boston, and laid in 1874 at Fort Jefferson, Dry Tortugas, Fla. They were so thoroughly rotted in 1878 that a cane was easily thrust through them.

One of your committee has heard it stated that the timber was simply swabbed over with an oil rag, and that the first works erected in Boston for creosoting would not stand 10 pounds pressure to the square inch, so that no effective work could be done.

Experiment No. 21 illustrates how necessary it is to know all the facts before forming a conclusion. Having been advised that favorable results had been accomplished at Rochester, N. Y., by the application of crude petroleum to farming machinery (experiment No. 21), the committee caused inquiries to be made in the oil regions as to the experience there.

Some general information was obtained as to the life of wooden oil tanks, duration of oil derricks, etc., etc., but it was rather indefinite.

At length a positive statement was received that on the Oil Creek Railroad, crude petroleum had been found to extend the life of hemlock ties to 14 years, and of oak ties to 18 years. That two gallons were required per tie, and that the ties, after being dried, should be put into boiling oil, the small end down. This seemed clear and definite, and the results promised to be so important that one of your committee went out to Titusville to investigate. He found that no ties had ever been actually treated by the process above indicated, but that it was thought that it would be the best way of applying petroleum should it be wished to preserve timber with it; that the experience consisted in observing the duration of ties in various side tracks on which crude oil was loaded, and where there was more or less dripping.

The side tracks were accordingly examined. Upon the principal one, still used as a track for loading oil, the ground was found to be completely saturated with petroleum; it oozed out and spurted up from beneath the ties upon the passage of each car, and here ties 12 or 13 years old were found to be as follows:

Hemlock, slightly dozy outside.
Black oak, " " "
White beech, dozy outside, sound inside.
White ash, sound and bright.
Black ash, " " "
White oak, perfectly sound.

Upon an adjoining side track, however, which had been used for loading oil for two or three years, and subsequently used for other purposes, the ties were found to have been once saturated with oil, but the ground was no longer in that condition. This side track was 9 years old, laid of hemlock ties, and these were badly rotted and in need of renewal.

The conclusion drawn was that crude petroleum, by excluding moisture, would prove a preservative so long as it continually saturated the wood, but that if merely injected once for all, its volatile nature would result in its evaporating out and leaving the timber unprotected.

Experiments Nos. 22, 23 and 24 illustrate the difference between good and bad work. Creosoting works at Galveston, Texas, creosoted in 1874 some 10 000 superficial feet of long leaf yellow pine paving blocks. The result was not satisfactory. The blocks upon being examined in 1881 showed that the creosote had penetrated the wood for about one-eighth of an inch only, and the center was dozy. Some other blocks, however, furnished for a stable yard (experiment No. 23), were of bastard or loblolly pine, which, in its ordinary condition, is a very perishable wood. These, when examined in 1885, proved to be perfectly sound, and upon being split open were found to be creosoted to the center.

The works above alluded to were principally established to creosote the

piles for the railroad bridge over Galveston Bay, which is some 2 miles long. This was in 1875 (experiment No. 24). In 1882, Mr. Temple, the Chief Engineer wrote:

"About one-half of the piles have been renewed, having been eaten by the *teredo*, caused evidently by dishonest creosoting, for last year, upon taking out the foundation of the draw bridge for the purpose of replacing it with brick, it was discovered that only two piles had been attacked out of a *selected lot* of 74."

"The piles were loblolly pine, known in most Southern States as 'fox tail,' or 'old field' pine, the life of which, not treated, is about two years here."

The next two experiments (No. 25 and No. 26) relate to the most thorough creosoting, and the most complete success which has been achieved in this country. They cover the preservation of timber both against the teredo and against decay, in the bridges of the New Orleans and Mobile Railroad, by Mr. J. W. Putnam, whose detailed account is given in Appendix No. 13. As this will be doubtless read in extenso, it seems sufficient to say here that it proves conclusively that when sufficient pains and expense are incurred creosoting is thoroughly efficient.

Experiment No. 27 relates to some 10 000 Virginia pine ties, which were creosoted in 1875–6, and laid upon the Central Railroad of New Jersey, beyond Bound Brook. These ties were allowed to season several months before being treated, and therefore absorbed the oil satisfactorily. They are now quite sound after seven or eight years' exposure, and are very little cut into by the rails.

Since then about 12 000 more have been treated at the Elizabethport works by Mr. Andrews, of this committee, whose views upon creosoting generally are herewith given in Appendix No. 14.

In this connection, we may allude to the "Webb" process (experiment No. 28), which dates back to 1871, and consisted in boring a hole lengthwise through the center of the tie or timber to be preserved, stopping up the hole with a plug, and then by a lateral hole, filling the cavity with creosote oil; the lateral hole being afterward plugged up with an iron screw, so that the operation could be repeated. A company with a capital of $2 000 000 was formed for the purpose of exploiting the portable boring machine with which the holes were to be bored, and of granting licenses to railroad companies upon a royalty of ten cents a tie. As the pores of the wood are mostly longitudinal with the grain, and are fewest and smallest about the heart, it was not found that the creosote thus barreled up in the ties disseminated itself much into the sap wood, especially during the winter, when creosote congeals at about 60° F. and becomes quite solid at lower temperatures.

Experiment No. 29 consisted of two yellow pine blocks, creosoted with 15 to 19 pounds to the cubic foot, which were furnished by Mr.

Andrews, and exposed with two untreated blocks from the same stick for 698 days in Delaware Bay. At the end of that time the untreated blocks were largely destroyed by the teredo, and the creosoted blocks were perfectly sound. It was also found that the latter had lost nothing in weight, thus indicating that the oil had resisted any chemical or mechanical tendency of the water to remove it.

The next five experiments (Nos. 30, 31, 32, 33 and 34) all pertain to the Hayford process as carried out by Mr. Andrews, and applied to ties, fence posts, piles and plank. The results are all favorable, so far as the limited time which has elapsed permits judgment to be formed.

Experiment No. 35 consists of some pine ties creosoted by Mr. Putnam, and laid in New Orleans. It may confidently be asserted that they will prove a success.

Experiment No. 36 represents the work done on the Houston and Texas Central, in creosoting ties at their own works at Houston, Texas. It has proved a success, and an interesting account of the process is given by Mr. M. G. Howe, in Appendix No. 15.

Experiment No. 37 consists in creosoting the piles in the long bridges across Lake Ponchartrain, New Orleans, for N. O. and N. Eastern R. R., the extension of the Cincinnati Southern Railroad. The company built its own works, and they have been under the superintendence of Mr. J. W. Putnam.

General Remarks on Creosoting.

It thus appears that there is no process of wood preserving the efficacy of which, when well done, is better established than creosoting, but there is also no process where more bad work has been done, either from design or ignorance. The reason of this will be apparent when the cost is considered.

Creosote now costs about one cent a pound, and the supply in this country is not equal to the demand, so that it has to be imported from England. For protection against decay alone, it seems necessary to inject by the present methods from 8 to 12 pounds per cubic foot, and this represents as many cents per cubic foot for the antiseptic alone. If we apply this to the smaller class of ties, averaging about 3 cubic feet each (and ties on many roads average 4 cubic feet), we have from 24 to 36 pounds (or cents) of creosote required for proper injection. To this is to be added the cost of handling the ties and working the plant, so that it may be said that properly to creosote ties will cost from 35 to 60 cents apiece, in accordance with their size and the amount of oil injected. This cost in most instances will be prohibitory, and it will generally be cheaper to let the ties rot and to replace them at present prices.

For timber in very wet situations or exposed to marine worms, creosoting is the only method which insures success. Whether it will

pay to use it will depend upon the exposure and the activity of the worms. Along the Gulf Coast, where the *teredo* cuts off a pile in eight months, there is no question about the matter, and creosoting *must* be resorted to. In our Northern harbors, where piles are destroyed in from five to twelve years, each case will have to be considered on its own merits. Where the sea water is fouled by sewage, or by the discharge of gas works, or the fermentation of vegetable refuse, such as the dust from an elevator, the *teredo* is inactive, or is driven away altogether, as he requires reasonably clean water to exist. For the same reason, he will not work much below the mud line. It is stated, however, that the *limnoria* is not injured by some varieties of sewage. How far these consideration may be relied upon will depend on the circumstances of each case, and it will not infrequently happen that it is cheaper, in view of cost and accruing interest, to let the *teredo* eat the piles, than to incur the expense of creosoting the timber to keep him out.

It seems to be established that it requires from ten to twenty pounds of creosote per cubic foot, depending upon the exposure, to protect timber against the *teredo*. The total cost, therefore, may be estimated at 14 to 24 cents a cubic foot, or $12 to $20 per 1 000 feet, b. m., for piles or square timber exposed to the attack of marine worms, and from 12 to 16 cents a cubic foot, or $10 to $14 per 1 000 feet, b. m , for timber exposed to decay alone.

There are creosoting works in this country as follows :

Somerset, Mass.....Old Colony Railroad.
Brooklyn, N. Y.....Eppinger and Russell.
Pascagoula, La.....New Orleans and Mobile Railroad.
Bonfouca, La.....New Orleans and Northeastern Railroad.
Houston, Texas.....Houston and Texas Central Railroad.
Summerville, S. C.....South Carolina Railroad.

Boucherie or Sulphate of Copper.

The name of Dr. Boucherie is generally applied to the *process* which he invented and extensively applied, of preparing wood by forcing a solution longitudinally through the pores of the wood by means of hydraulic pressure. As, however, he also patented the use of sulphate of copper, and his name became attached to the use of that antiseptic, it will be convenient here to classify experiments made with that substance under this head.

Dr. Boucherie was a distinguished French chemist, who between 1836 and 1846 made many elaborate researches and experiments upon the preservation of timber. He tried many substances, and at first recommended the use of pyrolignite of iron, but subsequently used sulphate of copper, which he considered more effective.

His first experiments were conducted by vital suction, that is, by tapping the living tree, and allowing the ascending sap to carry up a

preserving solution. This was not found to give uniform or satisfactory results, and Dr. Boucherie then invented the process which bears his name. This was practiced, either by applying a cap to the end of a freshly cut log, through which the solution was allowed to flow by pressure, or by sawing a log nearly through in the middle, raising it at the center slightly, so as to open the joint, placing a strip of tarred rope, or a rubber band, just inside the periphery of the cut log, and letting it spring back, so as to form a tight joint by pressing upon the rope or band. An auger hole bored diagonally into the cavity so formed then served to admit the solution under pressure.

This process, applied with a solution of about 1 pound of sulphate of copper to 100 pounds of water, has been extensively applied in France for many years, with satisfactory results. It was found, however, that to be successful it must be applied to freshly cut trees in the log only, and that this involved so much delay, moving about, waste and annoyance, that it has now been abandoned. These difficulties would be still greater in this country, and in the Northern States the process could not be applied at all during the winter (or season for cutting down trees), as the solution would freeze.

On page 279 is a list of the experiments which your committee have been able to learn about, as having been made with sulphate of copper in this country.

Comments on Sulphate of Copper Experiments.

The first experiment was carried out by Mr. W. W. Evans, on the Southern Railway of Chili, in 1857, and he informs your committee that in 1860, when he left that country, the ties were still good and in serviceable condition.

We give herewith, in Appendix No. 16, an interesting letter from Mr. E. Pontzen to Mr. Evans, on the subject of the Boucherie process.

Experiments Nos. 2 to 16, inclusive, were all tried with various modifications of the sulphate of copper process as introduced by Mr. W. Thilmany in this country. They date back to 1870 (experiment No. 2), when Mr. Thilmany was working and recommending the methods of vital suction and of the Boucherie hydraulic pressure system. After describing the foreign methods of injection with sulphate of copper, he states in his first pamphlet (1870): "This process resulted very satisfactorily, but it was found that the sulphate of copper became very much diluted by the sap, and when the same liquid was used several times, the decaying substance of the sap, viz., the albumen, was reintroduced into the wood, and left it nearly in its primitive condition."

He accordingly proposed a double injection, first by muriate of barytes, and secondly by sulphate of copper, forced through by the Boucherie process, and it is presumed that the ties of 1870, in experi-

RECORD OF AMERICAN EXPERIMENTS.

Sulphate of Copper, or Boucherie.

No.	Locality.	Year.	Process.	Material Treated.	Subsequent Exposure.	Results.	Authority.
1	Chili, S. A.	1857	Boucherie	Poplar ties	R. R. track	Favorable	W. W. Evans.
2	Cleveland, O.	1870	Thilmany	Ties	"	Favorable to 1875	J. R. Conrad.
3	Washington	1872	"	Paving blocks	Laboratory	Unfavorable	W. C. Tilden.
4	Pensacola	1874	"	Live oak	Teredo	Failure	W. H. Varney.
5	Charleston, S. C.	1875	"	Pine block	"	"	Q. A. Gilmore.
6	San Francisco	1876	"	"	"	"	C. S. Stewart.
7	Milwaukee	"	"	"	Pavement	Favorable, 1882	Schlitz Bg. Co.
8	Norfolk, Va.	"	"	Hackmetack	Teredo	Failure	P. C. Asserson.
9	Charlestown, Mass	1877	"	Various	Laboratory	Favorable	J. F. Babcock.
10	Wabash R. R.	"	"	Ties	R. R. track	Unfavorable	R. A. Houghton.
11	"	1878	"	"	"	"	W. S. Lincoln.
12	New York, Pennsylvania and Ohio R. R.	1879	"	"	"	"	C. Latimer.
13	Lake Shore and Michigan Southern R. R.	"	"	"	"	"	R. A. Houghton.
14	Cleveland and Pittsburgh R. R	"	"	"	"	"	C. Latimer.
15	Charlestown, Mass.	1879	"	Spruce plank	Sidewalk	Success to 1882	S. G. White.
16	Baltimore and Ohio	"	"	Ties	R. R. track	Too recent	J. L. Randolph.
17	Hudson River R. R.	1869	Hamar	"	"	Success	E. W. Vanderbilt.
18	St. Louis	1882	Fladd	"	"	Too recent	H. Fladd.

ment No. 2, which showed favorable results when examined in 1875, were prepared by that process.

Subsequently Mr. Thilmany changed his mode of application to the Bethell process of injecting solutions under pressure in closed cylinders, and probably the paving blocks for experiment No. 3 were prepared in that way. The chemical examination of them by Mr. Tilden, however, showed the "saturation very uneven; absortive power high; block contains soluble salts of copper, removable by washing."

It was expected that the double solution, by forming an insoluble compound, would prove an effective protection against the *teredo*. Experiments Nos. 4, 5, 6 and 8, however, proved the contrary to be the fact.

The process, when well done, gave moderately satisfactory results against decay. A pavement laid in the yard of the Schlitz Brewing Company, in Milwaukee (experiment 7), was sound in 1882, after some six years' exposure. A report by Mr. J. F. Babcock, a chemist of Boston (experiment No. 9), indicated favorable results, and the planks in a rope-walk at Charlestown (experiment No. 15), laid in 1879, were yet sound in 1882

The experiments on railroad ties (Nos. 10, 11, 12, 13, 14 and 16), however, did not result satisfactorily. They seemed favorable at first, and great things were expected of them; but late examinations made on the Wabash Railroad, on the New York, Pennsylvania and Ohio, and on the Cleveland and Pittburgh Railroad, have shown the ties to be decaying, and the results to be unfavorable.

This applies to the sulphate of copper and barium process. Mr. Thilmany has patented still another combination, in which he uses sulphate of zinc and chloride of barium, which has been noticed under the head of Burnettizing.

Experiment No. 17 was tried on the Hudson River Railroad. It consisted of 1 000 sap pine ties, which had been impregnated in the South, by the Boucherie process, with a mixture of sulphate of iron and sulphate of copper, under Hamar's patent. These ties were laid in the tunnel at New Hamburg, a trying exposure, and when examined, in 1882, several of them were still in the track. The process, however, was found to be so tedious that it was abandoned after a year's trial, and has not since been resumed.

In 1882 Mr. H. Fladd, of St. Louis, patented a method, which is the inverse of the Boucherie process (experiment No. 18). To the cap fastened to the end of a freshly cut log he applies a suction pump, and placing the other end into a vat, filled with the desired solution, he sucks up the preserving fluid through the pores or sap cells of the wood.

Quite a number of experimental ties have been prepared in this way, with various chemical solutions, chief of which was sulphate of copper,

and there is probably no question but that the life of the wood will be materially increased thereby.

Whether the process will prove more convenient and economical than the original Boucherie process can only be determined by practical application upon an extensive scale.

A considerable number of modifications and appliances for working the Boucherie process have been patented in this country; but none of them seems to have come into practical use, probably because of the necessity for operating upon freshly cut logs, and the inconvenience of such applications.

The table on page 282 gives a record of various experiments with miscellaneous substances.

Comments on Miscellaneous Experiments.

Experiments Nos. 1, 2 and 3 relate to the Earle process, from which great results were expected from 1839 to 1844. It consisted in immersing timber, rope, canvas, etc., in a hot solution of 1 pound of sulphate of copper and 3 pounds of sulphate of iron mixed in 20 gallons of water. It was first tested on some hemlock paving blocks on Chestnut street, Philadelphia, and for a time seemed to promise good results. Experiments with prepared rope, exposed in a fungus pit, by Mr. James Archbald, Chief Engineer of the Delaware and Hudson Canal, seemed also favorable.

The process was, therefore, thoroughly tried at the Watervliet Arsenal, where it was applied to some 63 000 cubic feet of timber, at a cost of about 7 cents per cubic foot. The timber was used for various ordnance purposes, and while it was found to have its life extended, as would naturally be expected from the known character of the antiseptics used, its strength was so far impaired, and it checked and warped so badly, that the process was abandoned in 1844.

The committee is indebted to General S. V. Benet, Chief of Ordnance, for a full copy of the reports upon these experiments.

Experiments Nos. 4 and 7 represent the lime process, which has been applied to a considerable extent in France. The fact that platforms and boxes used for mixing lime mortar seem to resist decay has repeatedly suggested the use of lime for preserving timber. In 1840 Mr. W. R. Huffnagle, Engineer of the Philadelphia and Columbia Railroad, laid a portion of its track on white pine sills, which had been soaked for three months in a vat of lime-water as strong as could be maintained. Similar experiments were tried on the Baltimore and Ohio in 1850. The result was not satisfactory, as might be expected from the fact that lime is a comparatively weak antiseptic (52.5 by atomic weight, while creosote is 216), and from the extreme tediousness of three months' soaking.

Experiments Nos. 5 and 8 were tried with sulphate of iron, sometimes known as Payenizing, and the particulars of the former have been fur-

RECORD OF AMERICAN EXPERIMENTS—MISCELLANEOUS.

No.	Locality.	Year.	Process.	Material Treated.	Subsequent Exposure.	Results.	Authority.
1	Chestnut street, Philadelphia	1839	Earle's	Hemlock blocks	Paving	Failure	S. V. Benet.
2	Watervliet Arsenal	1840	"	Oak timber	Gun carriage	"	"
3	Delaware & Hudson Canal	1840	"	Rope	Fungus pit	Favorable	"
4	Philadelphia & Columbia Railroad	1840	Lime bath	Pine stringers	Railroad track	Unfavorable	M. Coryell.
5	Boston & Providence Railroad	1844	Sulphate of iron	Ties	"	"	I. Hinckley.
6	Belvedere Railroad	1850	Salt	Hemlock	"	"	M. Coryell.
7	Baltimore & Ohio Railroad	1850	Lime	Ties	"	"	J. L. Randolph.
8	Rochester	1852	Payenizing	Ties	"	"	T. Hilliard.
9	Germantown, Ind	1855	Charring	Fence posts	Fence	Favorable, 1879	G. McGrew.
10	Pottsville, Pa	1857	Pyrolig'ite of iron	Timber	Railroad sills	Unfavorable	H. K. Nichols.
11	Erie Railway	1858	Boring	"	Bridges	Favorable	H. D. V. Pratt.
12	Galveston	1867	Casing	Piles	Bridge	Failure	W. H. Smith.
13	New York	1868	Beerizing	Lumber	Signs	Doubtful	S. Beer.
14	Wyoming Territory	1868	Natural soil	Ties	Railroad track	Preserved	J. Blinkinsderfer.
15	Chicago, Ill	1870	Foremanizing	Timber	Steamboat	Favorable, 1879	M. B. Brown.
16	Illinois Central Railroad	1871	"	Ties	Railroad track	Failure	L. P. Morehouse.
17	St. Louis	1871	"	Shingles	Roof	"	F. de Funiak.
18	Memphis & Charleston	1871	"	Ties	Railroad track	"	F. de Funiak.
19	Washington, D. C	1871	Tripler	Paving block	Laboratory	"	W. C. Tilden.
20	"	1872	Samuel	"	"	"	"
21	"	"	Taylor	"	"	"	"
22	Washington	"	Waterbury	"	"	"	"
23	"	"	Sulphate of iron	"	Pennsylvania ave	"	J. A. Partridge.
24	"	"	Sulphate of zinc	"	E street	"	"
25	"	"	Petroleum	"	16th street	"	"
26	Norfolk, Va	.....	Red lead	Pine and oak	Teredo	"	P. C. Asserson.
27	"	.....	White zinc	"	"	"	"
28	"	.....	Tar and plaster	"	"	"	"
29	"	.....	Kerosene	"	"	"	"
30	"	.....	Rosin and tallow	"	"	"	"
31	"	.....	Fish oil and tallow	"	"	"	"
32	"	.....	Verdigris	"	"	"	"
33	"	.....	Bark on pile	"	"	Good for 5 years	"
34	"	.....	Carbolic acid	"	"	Failure	"
35	"	.....	Tar and cement	"	"	"	"
36	"	.....	Davis' compound	"	"	"	"
37	"	.....	Carbolized paper	"	"	"	"
38	"	.....	Paint	"	"	"	"
39	"	.....	Thilmany	"	"	"	"
40	"	.....	Vulcanized fiber	"	"	"	"
41	"	.....	Charring	"	"	Good for 9 years	"
42	New Orleans & Mobile R. R	1872	"	Piles	"	Failure	J. W. Putnam.
43	" " "	"	" and oiling	"	"	Temporary prot'n	" "
44	Galveston & Houston R. R	{1870 / 1874}	Charring	"	"	" "	" "

nished by Mr. I. Hinckley, President of the Philadelphia, Wilmington and Baltimore Railroad, to whom your committee is much indebted for a large mass of information on the subject of timber preservation.

Mr. Hinckley has had longer and more varied experience on this subject than any other person in this country. Beginning with sulphate of copper in 1846, following with chloride of mercury in 1847, and chloride of zinc in 1852, going back to chloride of mercury, and again to chloride of zinc, using the latter until 1865, then using creosote to protect the piles against the *teredo* at Taunton Great River (experiment No. 2, creosoting), he has had millions of feet of timber and lumber prepared by the various processes, and has kindly placed at our disposal many original reports in manuscript and pamphlets which are now very rare.

Experiment No. 6 was made by Mr. Ashbel Welch, former President of this Society, and consisted in boring hemlock track sills 6 × 12 with a 1¼-inch auger-hole 10 inches deep every 15 inches. These were filled with common salt and plugged up, as is not infrequently done in shipbuilding, but while the life of the timber was somewhat lengthened, it was concluded that the process did not pay.

Salt has been experimented with numberless times. It is cheap, but is a comparatively weak antiseptic, its atomic weight being 58.8 in the hydrogen scale, as against 135.5 for chloride of mercury.

Experiment No. 9 is included in order to notice the well-known and most ancient process of charring the outside of timber. In this particular case, the fence posts after charring were dipped for about 3 feet into a hot mixture of raw linseed oil and pulverized charcoal, which probably acted by closing the sap cells against the intrusion of moisture, which, as is well known, much hastens decay. The posts, which had been set butt-end upward, were mostly sound in 1879, after 24 years' exposure.

Experiments Nos. 41, 42, 43 and 44 did not, however, result as well, and numberless failures throughout the country attest that charring is uncertain and disappointing in its results.

Much ingenuity has been wasted in devising and patenting machinery for charring wood on a large scale to preserve it against decay. The process, however, is so tedious in comparison with the benefits which it confers, and the charred surface is so objectionable for many uses, that nothing is to be expected from the process upon a large commercial scale.

In 1857-8 Mr. H. K. Nichols tried sundry experiments (No. 10), at Pottsville, Pa., upon timber which he endeavored to impregnate with pyrolignite of iron by means of capillary action. Similar experiments had previously been thoroughly tried in France by Dr. Boucherie, but the result has not been found satisfactory.

In 1858 the Erie Railway purchased the right of using the Nichols

patent, and erected machinery at its Owego Bridge shop for boring a 2-inch hole longitudinally through the center of bridge timbers. This continued till 1870, when the works were burned, and in rebuilding them the boring machinery was not replaced. The longitudinal hole allowed a portion of the sap to evaporate without checking the outside of the timber and undoubtedly lengthened its life. It is believed there are yet (1885) some sticks of timber in the bridges of the road that were so prepared in 1868 or 1869.

In 1867 Mr. W. H. Smith patented a method of preserving timber, by encasing it in vitrified earthenware pipes, and filling the space between the timber and the pipe with a grouting of hydraulic cement. This was applied to the railroad bridge connecting the main land with Galveston Island (experiment No. 12), and so well did it seem to succeed at first that it was proposed to extend the process to railroad trestle work, to fencing, to supports for houses, and to telegraph poles. But after a while the earthenware pipes were displaced and broken, the process was given up, and Galveston bridge is now creosoted.

In 1868 Mr. S. Beer patented a process for preserving wood by simply washing out the sap from its cells. Having ascertained that borax is a solvent for sap, he prepared a number of specimens by boiling them in a solution of borax. For small specimens, this answered well, and a sign-board treated in that way (experiment No. 13) was preserved a long time, but when applied to large timber the process was found very tedious and slow, and no headway has been made in introducing it.

Experiment No. 14 was brought about by accident. Some years ago it was discovered that there was a strip of road in the track of the Union Pacific Railroad, in Wyoming Territory, about 10 miles in length, where the ties do not decay at all. The Chief Engineer, Mr. Blinkinsderfer, kindly took up a cottonwood tie in 1882, which had been laid in 1868, and sent a piece of it to the committee. It is as sound and a good deal harder than when first laid, 14 years before, while on some other parts of the road cottonwood ties perish in 2 or 5 years.

The character of the soil where these results have been observed is light and soapy, and Mr. E. Dickinson, Superintendent of the Laramie Division, furnishes the following analysis:

Sodium chloride	10.64	Calcium carbonate	22.33
Potassium	4.70	Magnesium	3.39
Magnesium sulphate	1.70	Organic matter	4.20
Silica	0.09	Insoluble matter	941.47
Alumina	1.94	Loss in analysis	4.
Ferric oxide	5.84	Traces of phosphorus acid and ammonia.	

The following remarks made by the chemists who made the analysis may be of interest:

"The decay of wood arises from the presence in the wood of sub-

stances which are foreign to the woody fiber, but are present in the juices of the wood while growing, and consist of albuminous matter, which, when beginning to decay, causes also the destruction of the other constituents of the wood.

"One of the means adopted to prevent the destruction of wood by decay is by the chemical alteration of the constituents of the sap.

"This is brought about by impregnating the wood with some substance which either enters into combination with the constituents of the sap or so alters their properties as to prevent the setting up of decomposition.

"The analysis of this soil shows that it contains large quantities of the substances (sodium, potassium chloride, calcium and iron) most used in the different processes of preserving or Kyanizing wood. It also contains much inorganic matter, which also acts as a preserving agent."

Some of the ties so preserved have been transferred to other portions of the track, and some of the soil has also been transported to other localities, so that it is hoped that in the discussion which may be expected to follow this report, some further light will be thrown on the subject, by an account of the results of these experiments.

Experiments Nos. 15, 16, 17 and 18 are most instructive, and convey a useful lesson.

In 1865 Mr. B. S. Foreman patented the application of a dry powder for preserving wood, which was composed of certain proportions of salt, arsenic and corrosive sublimate. This action was based upon an experience which he had had, when, as a working mechanic of Ellisburg, Jefferson County, N. Y., in 1838, he had preserved a water-wheel shaft by inserting such a compound in powder in the body of the wood, and ascertained that it was still sound some 14 years later.

His theory of the action of his compound upon timber was briefly this:

"That all wood before it can decay must ferment; that fermentation cannot exist without heat and moisture; that the chemical property or nature of his compound, when inserted dry into wood, is to attract moisture, and this moisture, aided by fermentation, liquefies the compound; that capillary attraction must inevitably convey it through the sap ducts and medullary rays to every fiber of the stick. * * * * * Were these crystallizations salt alone, they would soon dissolve, but the arsenic and corrosive sublimate have rendered them insoluble; hence they remain intact while any fiber of the wood is left.

"The antiseptic qualities of arsenic are also well known, and have been known for centuries. Chemical analysis of the *mummies of Egypt* to-day shows the presence of arsenic in large quantities in every portion of their substance. Whatever other ingredients may have entered into the compound that has been so potent in preserving from decay the bodies of the old kings of Egypt, and even the linen vestments of their tombs, arsenic was most certainly one."

The mode of application used by Mr. Foreman was to bore holes two inches in diameter three-fourths of the way through sticks of square timber, four feet apart, to fill them with the dry powder, and to plug them up with a bung. For railroad ties he bored two holes two inches in diameter, six inches inside of the rails, and filled and plugged them. Fresh cut lumber and shingles were prepared by piling layers upon each other, with the dry powder sprinkled between in the ratio of twenty pounds to the thousand feet of lumber. This was allowed to remain at a temperature of at least 458° F. until fermentation took place, when the lumber was considered fully "Foremanized."

The process was first applied to the timber and lumber for a steamboat, and in 1879 the result was reported to be favorable. It was then applied to some ties on the Illinois Central Railroad, where it did not succeed, and to some on the Chicago and Northwestern, where they seem to have been lost sight of, being few in number, so that your committee has not been able to learn the result.

Great expectations were, however, entertained, and a conditional sale was made to various parties of the right of using the process, notably, it is said, to the Memphis and Charleston Railroad for $50 000; and some ten miles of ties were prepared on that road, when the poisonous nature of the ingredients used brought about disaster.

Some shingles were prepared for a railroad freight house at East St. Louis, but all the carpenters who put them on were taken very ill, and one of them died.

The arsenic and corrosive sublimate effloresced from the ties along the Memphis and Charleston Railroad. Cattle came and licked them for the sake of the salt, and they died, so that the track for ten miles was strewed with dead cattle. The farmers rose up in arms, and made the railroad take up and burn the ties. The company promoting Foremanizing was sued and cast in heavy damages, and it went out of business.

In 1870 Mr. A. B. Tripler patented a mixture of arsenic and salt, and the succeeding year a specimen of wood prepared under that patent was submitted to the Board of Public Works of Washington, D. C., and examined by its chemist, Mr. W. C. Tilden (experiment 19). He found the impregnation uneven, and the absorptive power high, but he did not find any arsenic, though its use was claimed.

The Samuel process (experiment 20) consisted in the injection, first, of a solution of sulphate of iron, and afterward of common burnt lime. Mr. Tilden reported the wood to be brittle, and the water used to test the absorptive power to have been filled with threads of fungi in forty-eight hours.

The Taylor process (experiment No. 21) used a solution of sulphide of calcium in pyroligneous acid. It was condemned by Mr. Tilden.

The Waterbury process (experiment 22) consisted in forcing in a solution of common salt, followed by dead oil or creosote. It was also condemned by Mr. Tilden.

The examinations of Mr. Tilden extended to some fourteen different processes, most of which have already been noticed in this report, and their practical results given.

The Board of Public Works, however, laid down a considerable amount of prepared wood pavement in Washington, all of which is understood to have proved a dismal failure. After a good deal of inquiry your committee has been enabled to obtain information of the results of three of these experiments.

The pine paving blocks upon Pennsylvania avenue (experiment 23) were first kiln-dried, and then immersed in a hot solution of sulphate of iron.

The spruce blocks on E street (experiment 24) were treated with chloride of zinc, or, in other words, Burnettized; but the mode of application is not stated.

The pine blocks upon Sixteenth street (experiment 25) were treated with the residual products of petroleum distillation. It is stated that this was the only process in which pressure was used.

In from three and a half to four and a half years the blocks were badly decayed, and large portions of the streets were almost impassable, while other streets paved in the same year with untreated woods remained in fair condition.

It has been stated to your committee that this result, which did much toward bringing all wood preserving processes into contempt, was chiefly owing to the very dishonest way in which the preparation was done; that in fact there was a combination between the officials and the contractors by which the latter were chiefly interested "how not to do it," and that the above results, therefore, prove very little on the subject of wood preservation.

Through the kindness of the United States Navy Department your committee is enabled to give the results of a series of experiments (Nos. 26 to 41, inclusive) which have been carried on at the Norfolk, Va., Navy Yard, for a series of years, by Mr. P. C. Asserson, Civil Engineer, U. S. N., to test the effect of various substances as a protection against the *teredo navalis*. It will be noticed that the application of two coats of white zinc paint, of two coats of red lead, of coal tar and plaster of Paris mixed, of kerosene oil, of rosin and tallow mixed, of fish oil and tallow mixed and put on hot, of verdigris, of carbolic acid, of coal tar and hydraulic cement, of Davis' patent insulating compound, of compressed carbolized paper, of anti-fouling paint, of the Thilmany process, and of "vulcanized fiber," have proved failures.

The only favorable results have been that oak piles cut in the month January and driven with the bark on have resisted four or five years, or till the bark chafed or rubbed off, and that cypress piles, well charred, have resisted for nine years.

This merely confirms the general conclusion which has been stated

under the head of creosoting, that nothing but the impregnation with creosote, and plenty of it, is an effectual protection against the *teredo*. Numberless experiments have been tried abroad and in this country, and always with the same result.

There are quite a number of other experiments which your committee has learned about which are here passed in silence. The accounts of them are vague, or the promised results of such slight importance as not to warrant cumbering with them this already too voluminous report.

The committee also forbears from discussing the merits of the many patents which have been taken out for wood preservation. It had prepared a list of them, and investigated the probable success of many of them, but has concluded that it is better to confine itself to the results of actual tests, and to stick to ascertained facts.

Neither does the committee feel called upon to point out the great importance of the subject, and the economical advantages which will result from the artificial preparation of wood as its price advances. They hope, however, that the members of this Society, in discussing this report, will dwell upon this point.

We shall instead give as briefly as possible the general conclusions which we have reached as the result of our protracted investigation.

Decay of Timber.

Pure woody fiber is said by chemists to be composed of 52.4 parts of carbon, 41 9 parts of oxygen and 5.7 parts of hydrogen, and to be the same in all the different varieties. If it can be entirely deprived of the sap and of moisture, it undergoes change very slowly, if at all.

Decay originates with the sap. This varies from 35 to 55 per cent. of the whole, when the tree is felled, and contains a great many substances, such as albuminous matter, sugar, starch, resin, etc., etc., with a large portion of water.

Woody fiber alone will not decay, but when associated with the sap, fermentation takes place in the latter (with such energy as may depend upon its constituent elements), which acts upon the woody fiber and produces decay. In order that this may take place, it is believed that there must be a concurrence of four separate conditions:

1st. The wood must contain the elements or germs of fermentation when exposed to air and water.

2d. There must be water or moisture to promote the fermentation.

3d. There must be air present to oxidize the resulting products.

4th. The temperature must be approximately between 50° and 100° F. Below 32° F. and above 150° F., no decay occurs.

When, therefore, wood is exposed to the weather (air, moisture and ordinary temperatures) fermentation and decay will take place, unless the germs can be removed or rendered inoperative.

Experience has proved that the coagulation of the sap retards, but does not prevent, the decay of wood permanently.* It is therefore necessary to poison the germs of decay which may exist, or may subsequently enter the wood, or to prevent their intrusion, and this is the office performed by the various antiseptics.

We need not here discuss the mooted question between chemists, whether fermentation and decay result from slow combustion (Eremacausis) or from the presence of living organisms (Bacteria, etc.), but having in the preceding pages detailed the results of the application of various antiseptics, we may now indicate under what circumstances they can economically be applied.

Selection of Preserving Process.

In view of the differing cost of the various antiseptics used, and of the price of timber in this country, where it is still much cheaper than in Europe, we believe that the method to be selected for preserving wood (if any) depends almost wholly upon its proposed subsequent exposure, and that it has been a mistake hitherto to look to a single process for all purposes.

If the timber is to be exposed, in sea water, to the attacks of the *teredo navalis* and *limnoria terebrans*, there is but one antiseptic which can be used with our present knowledge. This is creosote or "dead oil," and the amount of it necessary depends upon the activity of the *teredo*, or rather upon the length of time during the year when the temperature of the water renders them active.

In our northern harbors, probably 10 to 12 pounds of creosote to the cubic foot of timber are sufficient, but in southern seas it is probably necessary to inject from 14 to 20 pounds per cubic foot.

Whether it will pay to do this depends upon so many local circumstances in each case that this cannot well be discussed here. If the timber is to be exposed in a very wet situation, creosoting is also the best process to use. It will cost from $10 to $20 per 1 000 feet, b. m., or 35 to 60 cents per tie.

The selection of the oil, as well as the quantity, is of importance. It was formerly believed that the antiseptic properties of dead oil arose from the presence of carbolic and cresylic acid, but a very able paper by Mr. S. B. Boulton, the leading authority on creosoting in England, read before the British Institution of Civil Engineers in 1884, seems to establish the fact that the preserving properties of dead oil, aside from the mechanical effect in keeping out moisture, are chiefly due to "Acridine," or one of the alkaloids or bases now known to exist in creosote oils.

* Angus Smith, 1869, "Disinfectants." S. B. Boulton, 1884, Institution of Civil Engineers, "On the Antiseptic Treatment of Timber."

If the exposure is to be that of a railroad tie, creosoting is doubtless the most perfect process to use; but in view of the expense, it may be preferable to use a cheaper process, dependent somewhat upon the location, as away from the seaboard creosote is not available, and transportation is expensive.

Sleepers of Baltic fir, unprepared, 9 feet long and 10 x 5 inches, generally cost, in England, about 90 cents each, unloaded, grooved and piled; and creosoting adds about 24 cents to this. So that the sleeper costs about $1.14 ready to go into the track, and is there laid with a chair under the double-headed rail, so that the latter does not cut into the wood. These sleepers, therefore, last 18 to 20 years, while in this country they would probably be cut into by our foot-rail in from 12 to 16 years; and, moreover, as the first cost of our ties, of corresponding timber, say hemlock or mountain pine, is only from 25 to 35 cents, we cannot afford to spend an equal sum in preserving them; and creosoting is notoriously more expensive here than in England.

With our present knowledge, and as a result of this investigation, we believe that Burnettizing is the advisable process to use for ties at present in this country. This, if well done (and it is nearly useless to do it otherwise), will cost 20 to 25 cents per tie, and a discussion of the economical results to be expected therefrom will be found in Appendix No. 17, this being a report made by Mr. Chanute to the New York, Lake Erie and Western Railroad in 1883, which that company kindly allows to be published.

Good results may be accomplished with sulphate of copper, but not only does this salt render wood brittle (more so, it is believed, than chloride of zinc), but as the copper attacks iron vessels, its use necessitates preserving cylinders of copper, and requires an expensive plant.

The great defect of all mineral salts is that they are easily soluble in water, and so wash out in time, and leave the timber unprotected. Hence the many attempts to patent some method of retaining them in the wood. What these may be worth must be determined by time, but the desirable combination for this country would seem to be the impregnation of the inside of the tie with some metallic salt to poison the germs of decay, and a thin coat of creosote outside to repel the intrusion of moisture.

If the timber is to be exposed in a comparatively dry situation, as in bridges, a trestle or a fence, the results of this investigation indicate that Kyanizing is a good process to use. It does not seem to impair the strength of the timber as much as Burnettizing, and the latter accordingly is not recommended for those parts of structures (chords, ties, etc.) which are to bear tensile strains.

Kyanizing costs about $6 per 1 000 feet, b. m., and success with it cannot be expected unless the work be well done. Caution will need to be observed in carrying it on, as corrosive sublimate is a violent poison.

Modes of Application.

The various modes of preserving wood which have been experimented with may be summarized as follows:

1st. Injecting in closed cylinders under pressure.
2d. Steeping or immersion.
3d. Boucherie process, hydraulic pressure to the log.
4th. Exposure to vapors.
5th. Absorption by capillary action.
6th. Inward insertion of powders or liquids.
7th. Charring. Application of heat.
8th. Painting.

The first three are the only ones which need concern us, and of these the first is on all accounts the best, most effective, and most expeditious. It is believed to be nearly impracticable to use on a commercial scale any of the other modes of application for the injection of antiseptics.

Conditions of Success.

It has already been stated that success in wood preservation has heretofore been the rule in Europe, and the exception in this country. This has chiefly resulted from the fact that, timber being cheap and interest high, it was generally more economical to let the wood rot than to go to the expense of doing the work well, and the business accordingly drifted mainly into the hands of designing men and quacks. The advancing price of timber, however, which has about doubled within the last twenty years, and the decline in the rate of interest, which has dropped about one-third within the same period of time, now make it practicable, and in many cases necessary, to preserve wood against decay in many parts of this country.

Your committee will therefore attempt to state the principal conditions to be observed to achieve success, so far as they have been disclosed by this investigation.

1. Select the appropriate process, in view of the subsequent intended exposure of the timber.

2. Select the more open-grained, porous and sappy varieties of wood to operate upon.

Antiseptics penetrate but little into the dense structure of white oak, burr oak and yellow or heart pine, and are of doubtful utility for white pine, chestnut or spruce, while they readily impregnate and preserve the following varieties of wood:

Hemlock,	Black oak,
Sweet gum,	Red oak,
Mountain pine,	Gray oak,
Loblolly pine,	Water oak,

Beech,	Sour oak,
Poplar,	Cottonwood,
Ash,	Maple.

Mr. J. B. Francis found in Burnettizing that white birch with the bark on was well preserved, while in hewed white birch the decay was complete, probably because of the difference in density and penetrability of the sap wood and the heart wood.

The experience of the English engineers is to the same effect, and they prefer to employ for creosoting the more open-grained kinds of wood, and sap wood rather than heart.

It will be found that there are great differences in the density of wood grown in various localities and sections of the country.

3. Operate upon the cheaper woods. Not only is the preserving effect less upon the more valuable kinds, but they are more durable naturally, and it is a question whether at present prices it will pay to prepare them against decay. The cheap woods, on the contrary, can be made to outlast the best woods in their natural state by a thorough artificial preparation.

For railroad ties it will be advisable to select the harder kinds of wood to guard them against cutting into by the rails, especially upon curves. Preservation, however, materially adds to the natural hardness of timber, and it is found to resist cutting by the rail, under ordinary traffic, from 12 to 16 years.

4. Extract the sap and water, as far as practicable, before injecting the preservative. It is obvious that a liquid solution cannot be forced in, unless there is a place for it, and yet most of the failures of valuable methods can be traced to neglect of this obvious requirement. Timber must be well seasoned either naturally or artificially before the antiseptic is injected, except in the case of the Boucherie process, which can only be applied to freshly cut logs.

The Europeans operate, as has been stated, upon timber which has been cut and seasoned six months or more, and hence they find little trouble in injecting the solutions. In this country we must operate chiefly upon green or freshly cut timber, and hence must resort to steaming, if we use the pressure method of injection. Very good results are accomplished by steaming, but the work must be well done, and at such heat and pressure as not to injure the fiber.

5. Put in enough of the antiseptic to accomplish the desired result, and make sure that its quality and strength are such as neither to injure the fiber of the wood nor to leave it unprotected.

6. After the wood is prepared allow it to dry as much as practicable before using. Its durability will be materially increased by getting rid of surplus moisture.

7. Let there be no undue haste in carrying on the work. This is sure to result in unsatisfactory preparation.

8. In laying prepared ties or timber in the track protect them from moisture or water, as far as practicable, by draining the road-bed.

9. Contract with none but reliable parties. As an inspection subsequent to the doing of the work, short of chemical analysis, does not establish the fact whether it has been well done, and the results cannot be detected for some years, there will always be a great temptation to do bad or careless work under contracts. The safe course, therefore, for those who decide to have timber preserved is either:

A. To do the work themselves, under the supervision of experts;

B. To contract it at a sufficient price to honest and skillful parties, keeping an inspector at the works to note the daily working when the magnitude of the order will warrant it; or,

C. Contract the work on such terms that the profits shall depend upon the results accomplished in preserving the wood against decay.

Will it Pay?

The question as to whether it will pay to preserve timber against decay seems to have been answered very positively in the affirmative in Europe. There seems to be, indeed, no longer any question there about it; preservation is looked upon as quite a matter of course, and public works which fail to avail of it are alluded to as neglecting an important economy.*

In this country, preservation of wood (except in an experimental way) has been the rare exception, but the time has probably arrived when, in many sections, an economy of twenty to fifty per cent. a year can be obtained in the maintenance of timber structures and cross-ties, by preparing them artificially to resist decay, while in other sections timber is still too cheap to warrant spending money to preserve it.

This depends upon the price. Thus where a white oak tie costs twenty-five cents and lasts eight years, if we spend twenty-five cents more in preparing it so that it will last sixteen years, we but double the life as well as the cost, and save only the expense of taking the old tie out, and placing the new tie in the track, at the end of the first eight years, if the price of ties in the meanwhile continues the same.

If, however, the oak tie costs seventy-five cents, and we can substitute a hemlock tie, which would unprepared last three and a half years, and cost thirty cents, and by preparing it extend its life to twelve years, at an additional cost of twenty-five cents, or even more, we then have a notable economy, both in first cost and in duration.

In the case of piles, which are cut off by the *teredo* in one or two years, as occurs in our Southern harbors, the case is plain. They must be creosoted, or great waste and increased expense will result. In cases

* Funk's paper, Appendix No. 6. Discussion of Boulton, "The Antiseptic Treatment of Timber."

where they last eight to ten years, as in some Northern sections, it will depend partly upon the value of the structure which the piles sustain whether it will pay to creosote them or not.

In the case of bridges and trestles, much will depend upon the exposure, and the cost of maintenance, as well as upon the proximate exhaustion of suitable timber in the vicinity, and upon contemplated permanent renewals, while in the case of buildings, platforms, floors, etc., the ordinary wear from traffic will also have to be taken into account.

The most important factor will be the exposure (wet or dry), and consequent rate of decay. Thus all brewers find it very economical to preserve their floors; and mills, bleacheries, dye-houses, etc., largely resort to artificial preparation of timber because of their exposure to slopping of water, and consequent moisture in heated apartments.

The engineers and managers of the several works, therefore, will have to figure up for themselves, in view of the local circumstances of their case, and the present and prospective price of timber, whether the economy of artificial treatment is sufficiently attractive to induce them to resort to it.

The great consumers of timber are the railroads, and the managers of such enterprises have to be governed by a good many considerations, both of finance and of expediency, besides those of eventual economy.

Hitherto, aside from the past cheapness of timber, the principal objections to its preparation against decay have been the lack of information as to what results could be confidently expected, and the conflicting claims of the promoters of various modes of treatment, each of whom represented his process as absolutely the best under all circumstances.

The committee hopes that this report of the results of its investigations during the past five years will have done something toward removing the above mentioned obstacles to an important economy, but there still remains the objection that the results to be accomplished are somewhat remote, while the expenditure must be immediate.

Railroad managers naturally want to obtain immediate returns. They do not like to burden the revenues of the current year for the benefit of future administrations, and they are with reason jealous of every dollar that goes out now, even if it promises to save two or three dollars in the future; yet, now that close competition requires every possible economy to be availed of, that railroads must more largely depend upon saving money in their maintenance, in order to continue or to resume their dividends, and that companies in good standing can obtain new capital for expense-saving appliances at four and one-half or five per cent. a year, the time has probably arrived, in view of advancing prices and scarcity of timber, when some leading railroads will take steps to preserve it.

Computations of the money saving to be effected will be found in Appendix No. 6 and in Appendix No. 17.

In the former, Privy Councillor Funk estimates that in 1878, out of sixty millions of sleepers on the German railroads, twenty-five millions were impregnated, and that even with the extraordinary length of life stated for unprepared ties (13.6 years for oak and 6.1 for fir and pine), had the remaining thirty-five millions of ties been impregnated, there would have been a resulting economy of about one million of dollars a year, or some thirty-three per cent. on the cost of renewals.

This estimate is understood as having resulted in a material extension of tie-preserving in Germany, notwithstanding the fact that metallic ties have already been largely introduced in that country.

As regards the latter, a simple calculation shows that the time has not yet arrived when they can profitably be introduced in this country. They will cost, laid in the track, about $2.50 each, and were they to last forever (the estimated life in Germany is 20 to 40 years), the interest on the cost, at 5 per cent., would be 12½ cents a year a tie, or more than the annual charge of an unprepared white oak tie, costing 77 cents in the track, and lasting 7 years.

If, instead of 13.6 years for oak, and 6.1 years for fir and pine, unprepared, which life is said to obtain in Germany (probably in consequence of more thoroughly drained and ballasted road beds than our own), we assume a life of 8 years for oak, and 4 years for mountain pine and hemlock, as in better accord with experience in this country, we shall have the following computations of economy, upon the basis of Councillor Funk's paper, when oak sells at 50 cents, and hemlock at 25 cents a tie:

UNPREPARED TIES.

	Annual Charge.
15 000 000 oak, @ 50 c. = $7 500 000 ÷ 8	$937 500
20 000 000 hemlock, @ 25 c. = $5 000 000 ÷ 4	1 250 000
	$2 187 500

If it costs 25 cents each to impregnate them, we then have for lives of 16 and 12 years:

PRESERVED TIES.

	Annual Charge.
15 000 000 oak, @ 75 c. = $11 250 000 ÷ 16	$703 125
20 000 000 hemlock, @ 50 c. = $10 000 000 ÷ 12	833 333
	$1 536 458

Annual economy, $651 042.

When, however, the prices have advanced to 75 cents for the oak, and 30 cents for the hemlock, we have, with the same life and cost of preparation, the following comparison:

UNPREPARED TIES.

	Annual Charge.
15 000 000 oak, @ 75 c. = $11 250 000 ÷ 8	$1 406 250
20 000 000 hemlock, @ 30 c. = $6 000 000 ÷ 4	1 500 000
	$2 906 250

PRESERVED TIES.

15 000 000 oak, @ $1 = $15 000 000 ÷ 16	$937 500
20 000 000 hemlock, @ 55 c. = $11 000 000 ÷ 12	916 667
	$1 854 167

Annual economy, $1 052 083.

This illustrates how the economy of preservation increases as the price of ties advances.

The above mode of calculation is not strictly accurate. It omits the interest account, which would increase the cost as against the prepared ties, and it also omits the cost of periodical renewals, which would increase the cost of the unprepared ties.

Various methods have been employed for computing the economy of renewable structures. Local conditions and considerations vary so much, and there are so many circumstances which will force themselves into the account, that it is, perhaps, not wise to state any very definite rule in the premises. Your committee submit, however, three methods for such calculations in the appendix.

Appendix No. 18 is an estimate of the economy of creosoting ties, by Mr. E. R. Andrews, of this committee. Appendix No. 19 is an estimate of what increased life is necessary in order to justify a certain rate of expenditure in preserving timber, by Mr. B. M. Harrod, also of this committee, and Appendix No. 20 contains a formula for estimating the economy of various kinds of ties, furnished to your committee by an expert in such matters, the late Mr. Ashbel Welch, then President of this Society, and who thus renders a last service to the Society which regrets him still.

Respectfully submitted.

O. CHANUTE,
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Committee on the Preservation of Timber.